University of Alberta

Nutrition and Weight Status of Cree Children

By

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ABSTRACT

Dietary intake, the home food environment and physical activity/fitness were assessed in 178 Cree schoolchildren from two communities in northern Quebec. Children had high rates of overweight (30.3%) and obesity (34.8%). Fruit and vegetable, milk and fiber intake were significantly associated with reduced odds of overweight/obesity. Children reported availability of pop, milk and real fruit juice in the home was associated with their intake. Children who consumed 3 or more meals (18%) from restaurant/take-out during the three days of dietary recalls had a poorer diet than children who consumed fewer restaurant/take-out meals. The top contributing foods to the diet were primarily energy dense foods of low nutritional value. We report a high risk of folate, zinc and vitamin A inadequacy. Milk and traditional foods were important food sources of micronutrient intake. Physical activity and fitness levels were low. Our findings provide evidence for the need for culturally sensitive interventions that target healthy body weights, physical activity and nutritious diets in Cree schoolchildren.

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TABLE OF CONTENTS

1. INTRODUCTION 1
  1.1 LITERATURE CITED 4

2. LITERATURE REVIEW 6
  2.1 DESCRIBING OBESITY IN CANADIAN CHILDREN 6
    a. Overweight, Obesity, and Adiposity 6
      i. Body Mass Index (BMI) 7
      ii. International Obesity Task Force (IOTF) 8
      iii. Center for Disease Control and Prevention Growth Charts 8
      iv. Waist Circumference 9
      v. Conclusion 10
    b. Obesity in Canadian Children & the Aboriginal Population 11
    c. Obesity in children is a health problem 12
  2.2 THE ETIOLOGY OF OBESITY 16
    a. General Discussion 16
    b. The nutrition environment 19
    c. Dietary and Physical Activity Recommendations for children 20
      i. Dietary Recommendations 21
      ii. Physical Activity Recommendations 22
    d. Validity, Reliability, Bias and Accuracy of Measurement Tools 23
    e. Measurement tools 24
      i. Measurement of dietary intake in children 24
      iii. Measurement of the home food environment 27
      iv. Measurement of Physical Activity & Fitness in children 28
        - Pedometers 29
        - 20-meter shuttle run test (20 MST) 31
    f. Diet, Physical Activity, Sedentary Behavior and Childhood obesity 32
      i. Conclusion 39
  2.3 RESEARCH GAPS IN ABORIGINAL RESEARCH 40
  2.4 LITERATURE CITED 42

3. OBESITY, DIET, PHYSICAL ACTIVITY AND FITNESS IN CREE CHILDREN 56
  3.1 INTRODUCTION 56
  3.2 SUBJECTS & METHODS 57
    a. Weight Status 58
    b. Physical Activity and Fitness 59
    c. Dietary Intake 59
    d. Statistical Analysis 61
    e. Ethics 61
  3.3 RESULTS 61
  3.4 DISCUSSION 64
  3.5 STRENGTHS & LIMITATIONS 70

3.6 CONCLUSION 71
3.7 LITERATURE CITED 81

4. RESTAURANT INTAKE AND THE HOME FOOD ENVIRONMENT OF CREE CHILDREN 88
4.1 INTRODUCTION 88
4.2 SUBJECTS & METHODS 90
a. Weight Status 91
b. Physical Activity and Fitness 92
c. Dietary Intake 92
d. Restaurant and Take-out Food 93
e. The home food environment 93
f. Statistical Analysis 94
4.3 RESULTS 94
4.4 DISCUSSION 96
4.5 STRENGTHS & LIMITATIONS 101
4.6 CONCLUSION 102
4.7 LITERATURE CITED 106

5. MICRONUTRIENT INTAKE AND FOOD SOURCES IN CREE SCHOOLCHILREN 112
5.1 INTRODUCTION 112
5.2 SUBJECTS & METHODS 112
5.3 RESULTS 114
5.4 DISCUSSION 115
5.5 CONCLUSION 118
5.6 LITERATURE CITED 123

6. SUMMARY AND CONCLUSIONS 125
6.1 FINAL COMMENTS 130
6.2 FUTURE DIRECTIONS 131
6.3 LITERATURE CITED 133

APPENDICES 138

APPENDIX A 139
INFORMATION SHEET 139

APPENDIX B 142
CONSENT FORM 142

APPENDIX C 145
24-HOUR RECALL 145

APPENDIX D **146**
HOME FOOD AVAILABILITY 146

APPENDIX E **147**
FOOD CATEGORIES 147

APPENDIX F **149**
ANTHROPOMETRIC MEASURES DATA SHEET 149

APPENDIX FORMS

Appendix A INFORMATION SHEET

Appendix B CONSENT FORM

Appendix C 24-HOUR DIETARY RECALL FORM

Appendix D FOOD AVAILABILITY QUESTIONNAIRE

Appendix E FOOD CATEGORIES

Appendix F ANTHROPOMETRIC DATA SHEET

LIST OF TABLES

Table 3-1 The association of weight categories with dietary and non-dietary variables..72

Table 3-2 Normal weight versus overweight/obesity and waist circumference above or below the 85th percentile of NHANES III.................................74

Table 3-3 The correlation between pedometer scores and shuttle run times among weight categories...75

Table 3-4 The top 10 contributing foods to calories and calories from fat by weight Status..76

Table 3-5 The unadjusted odds ratios for lifestyle factors and reduced odds of overweight/obesity...77

Table 3-6 Consuming 5 or more USDA servings of fruits and vegetables per day in relation to weight status...78

Table 3-7 Consuming 2 or more servings of milk per day in relation to weight status..79

Table 3-8 Fiber intake in relation to weight status.......................................80

Table 4-1 The association of frequency of restaurant/take-out intake meals in the three days of recall with dietary and non-dietary variables...................103

Table 4-2 The child reported household availability of food in relation to actual intake..105

Table 5-1 Micronutrient intake and the risk of inadequacy..............................120

Table 5-2 Top five dietary contributors to vitamin's A, D, C and iron, zinc, calcium and folate..122

LIST OF ABBREVIATIONS

AI: Adequate Intake

ANOVA: Analysis of Variance

NHANES: National Health and Nutrition Examination Survey

BMI: Body Mass Index

CCHS: Canadian Community Health Survey

CDC: Center for Disease Control and Prevention

DRI: Dietary Reference Intake

EAR: Estimated Average Requirement

FFQ: Food Frequency Questionnaire

IOTF: International Obesity Task Force

RDA: Recommended Dietary Allowances

RHS: Regional Longitudinal Health Survey

20 MST: 20 Meter Shuttle Run Test

KSDPP: Kahnawake Schools Diabetes Prevention Program

$VO_{2\,MAX}$: Maximal Oxygen Uptake

DEXA: Dual-energy X-ray absorptiometry

CT: Computed tomography

BIA: Bioelectrical Impedance

MRI: Magnetic resonance imaging

NCHS: National centre for health statistics

WHO: World Health Organization

USDA: United States Department of Agriculture

1. INTRODUCTION

Aboriginals are the descendents of the original peoples of North America (Health Canada, 2003). In Canada, there are three groups of Aboriginal peoples identified in the Constitution- First Nations, Métis and Inuit (Health Canada, 2003). First Nations peoples are all indigenous people in Canada whom are not Inuit or Métis (Health Canada, 2003). The Métis are Aboriginal people of mixed First Nations and European ancestry and the Inuit are Aboriginal people of Arctic Canada who primarily live in Nunavut, the Northwest Territories, and northern parts of Quebec and Labrador (Health Canada, 2003).

The First Nations who participated in the research project outlined in this thesis, are the Cree of the James Bay Territory. Approximately 14,000 Cree people, the Eeyou of Eeyou Istchee, reside in the James Bay Territory of Northern Quebec (Torrie , Bobet, Kishchuk, & Webster, 2005). The territory consists of nine communities: Chisasibi, Eastmain, Mistissini, Nemaska, Ouje-Bougoumou, Waskaganish, Waswanipi, Wemindji, and Whapmagoostui (Torrie et al., 2005). Five communities are remote and established along the shores of James Bay while the remaining four communities are inland (James Bay Municipality, 2006). Chisasibi is the largest of the nine communities with a population just under 4,000 people (Torrie et al., 2005). The foci of this research were the largest inland community, which was situated near to a lake, with an approximate population of 3,500 people, and the second largest coastal community with a population of approximately 2,000 people (Torrie et al., 2005).

Aboriginal people have a poorer health status than other Canadians (Health Canada, 2003). Infectious disease, injuries, suicide, heart disease and diabetes disproportionately affect Aboriginal people (Health Canada, 2003). In recent decades, increasingly high obesity prevalence and consequently high chronic disease rates have been reported in Aboriginal communities in North America (Kuhnlein, Receveur, Soueida, & Egeland, 2004). Lower quality housing, poorer physical environments, lower education levels, lower socioeconomic status, fewer employment opportunities and weaker community infrastructure in many Aboriginal communities have resulted in inequities in the conditions that determine health (Health Canada, 2003).

In addition to the social conditions affecting the health of Aboriginals, the dietary patterns of Aboriginals have undergone substantial transition during recent centuries (Gittelsohn et al., 1998). The traditional diet of the Northern lifestyle was based mainly on hunting and fishing; the diet being high in protein, moderate in fat, and low in carbohydrate and fiber (Gittelsohn et al., 1998). With the arrival of fur traders in the 18th Century there was an introduction of European foods such as salted meat, flour, oatmeal, sugar, lard and tea into the diet (Gittelsohn et al., 1998). Furthermore, since the mid 1900s, the increase in permanent settlements has resulted in a growing dependence on store-bought foods and a decrease in the importance of hunting and fishing (Gittelsohn et al., 1998; Willows, 2005; Simoneau & Receveur, 2000; Harris, Perkins, & Whalen-Brough, 1996). Inadequate access and the inflated cost of healthy foods on many reserves and reservations has led to the consumption of increasing amounts of high-fat and high-sugar foods (Curran et al., 2005). Diets of low nutritional quality and high energy density have replaced the nutrient rich diets of the past.

The lifestyle changes that have occurred in the Aboriginal population in recent years have coincided with increases in lifestyle related diseases such as obesity and type 2 diabetes. There is a paucity of research that examines the relationship between lifestyle factors and weight status in Aboriginal children. It is necessary to identify and understand the factors that influence the health of Aboriginal children in order to develop feasible chronic disease prevention programs. The research project, conducted in two James Bay Territory communities, was developed to meet the following objectives with three studies.

Study 1

- To report the prevalence of overweight and obesity of Cree children.
- To describe the dietary quality of Cree children.
- To describe physical activity and physical fitness levels of Cree children.

Study 2

- To describe the home food environment and restaurant intake behavior of Cree children.

Study 3

- To report the risk of micronutrient inadequacy and micronutrient food sources of Cree children.

The information obtained from the aforementioned studies could be used to develop culturally sensitive interventions to prevent obesity in Cree children.

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2. LITERATURE REVIEW

2.1 DESCRIBING OBESITY IN CANADIAN CHILDREN

a. Overweight, Obesity, and Adiposity

It is important to understand the differences among obesity, overweight and adiposity and their respective risks for co-morbidities. Definitions of overweight and obesity should correspond with the degree of body fat at which health risks to individuals increase (Hubbard, 2000). However, creating these risk related definitions is a difficult task as longitudinal studies must be performed from childhood into adulthood to fully understand the pathology of obesity related disease as an individual ages.

The World Health Organization (2000) defines obesity as a disease in which excess body fat has accumulated to the extent that health has been compromised. Obesity indicates that excess weight for height is due to adiposity, whereas overweight denotes excess weight for height without regard for the composition of the weight (Troiano & Flegal, 1999). To assess overweight, only a measure of height and weight is needed; however, to measure obesity a measurement of adiposity is required (Troiano & Flegal, 1999). Calipers, dual-energy X-ray absorptiometry (DEXA), magnetic resonance imaging (MRI), computed tomography (CT) and bioelectric impedance (BIA) are all instruments used to measure adiposity and obesity (Troiano & Flegal, 1999). Nevertheless, for many purposes, weight for height can serve as a proxy measure of adiposity (Troiano & Flegal, 1999). Many researchers consider body mass index (BMI) to be a crude index of adiposity (Nevill, Stewart, Olds, & Holder, 2006) and from a public health perspective, BMI and its cut-off values for overweight and obesity are necessary to help describe populations and weight status trends (Hubbard, 2000).

i. Body Mass Index (BMI)

Growth assessment is the most useful means for defining health and nutritional status in children (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, & Community Health Nurses association of Canada, 2004). BMI is an anthropometric index of height and weight, defined as weight in kilograms divided by height in meters squared (kg/m^2) (Dietitians of Canada et al., 2004). BMI is universally used and accepted as a crude means of classifying adiposity. In adults, a BMI of 18.5-24.9 kg/m^2 is classified as being normal weight, a BMI of 25-29.9 kg/m^2 is referred to as overweight, and a BMI over 30 kg/m^2 denotes obesity (Nieman, 1999). Many studies have shown increased health risk with a BMI in the 25-30 kg/m^2 or above range and thus BMI has been established as a useful marker for disease status (Nieman, 1999). Correlation between BMI and body fatness is generally thought to be quite strong ($r \approx .80$) (Rodriguez, 2004). BMI cut-offs are a relatively good criterion for the screening of excess body fat but it is important to note the possibility of misclassification (Rodriguez, 2004).

A single BMI cutoff value for all ages, as used in adults, is not applicable for use in children and adolescents (Troiano & Flegal, 1999). The marked changes in growth and body composition during different periods of childhood and adolescence result in the necessity of using age- and sex-specific BMI cut-off values (Troiano & Flegal, 1999). To date, there has been controversy both in terms of a globally applicable reference population as well as the selection of appropriate cut-off points for designating a child as obese (WHO, 2000). The most widely used reference cut-offs for defining overweight and obesity in children are the International Obesity Task Force (IOTF) cut-offs (Cole, Bellizzi, Flegal, & Dietz, 2000) and the Center for Disease Control and Prevention (CDC) (CDC, 2005) growth charts.

ii. International Obesity Task Force (IOTF)

Data on children's body mass index from six large nationally representative surveys on growth from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States were pooled to develop the IOTF cut-offs to define overweight and obesity in children and adolescents (Cole et al., 2000). Each survey was comprised of over 10, 000 subjects with ages ranging from birth to 25 years. Centile curves of BMI by sex and age were constructed for each data set. The centile curves were extrapolated to adult cut-offs of 25 and 30 kg/m^2 to denote overweight and obesity, respectively (Cole et al., 2000; Dietitians of Canada et al., 2004). The cut-off points have the potential to be broadly applied to the population to determine whether children and adolescents are at greater risk of morbidity related to overweight and obesity, and their use is advised when comparing groups with international standards (Cole et al., 2000).

iii. Center for Disease Control and Prevention Growth Charts

The 2000 CDC growth charts were adapted from the 1977 growth charts developed by the National Centre for Health Statistics (NCHS) (CDC, 2005). When the 1977 NCHS charts were developed it was recommended that they be revised periodically (CDC, 2005). Data from the National Health and Nutrition Estimation Survey (NHANES) II and NHANES III were used to update the 1977 NCHS growth charts to create the 2000 CDC growth charts (CDC, 2005). Age and sex related BMI values were developed using the reference data to replace the former weight-for-stature charts (CDC, 2005). The charts were revised and updated to enable them to be a more clinically valuable tool for health professionals (CDC, 2005). Using BMI, the charts examine weight in relation to stature for children and adolescents 2 to 20 years old (CDC, 2005). The charts are segregated by both sex and age and have percentile cut-offs that are associated with indicators of nutritional status (CDC, 2005). A BMI for age that is between the 85th and the 95th percentile of the reference population corresponds with a classification of being "at risk of overweight" whereas a BMI for age over the 95th percentile corresponds to a classification of being "overweight" (CDC, 2005).

iv. Waist Circumference

In recent years, waist circumference measurement has emerged as one of the more popular anthropometric means of measuring obesity and obesity related health risk. Waist circumference is recommended as an indicator of obesity-related health risk in adults because it is correlated with visceral adipose tissue, which is predictive of chronic disease and premature mortality (Katzmarzyk, 2004). Furthermore, waist circumference appears to be a good predictor for the screening of the metabolic syndrome in both adults and children (Rodriguez, 2004; Esmaillzadeh, Mirmiran, & Azizi, 2006). Several studies have found that waist circumference coupled with BMI is more useful in predicting cardiovascular disease and its corresponding risk factors than is BMI alone (Janssen, 2004). The WHO (2000) recommends using waist circumference as a supplementary measure to BMI for measuring body size in children and adolescents. By performing waist circumference measurements researchers will have a better indication of centralized adiposity in addition to risk for disease in the present and future. However, to date the WHO does not have waist circumference reference data to monitor child and adolescent growth. Nevertheless, various countries have developed their own waist circumference reference data for their pediatric and adult populations. In Canada, Katzmarzyk (2004) developed percentile references to be used for identifying youth with an elevated risk of developing obesity related disorders. Data from 3,064 11-18 year old youth from the 1981 Canada Fitness Survey were used to develop the reference data percentiles. Unfortunately, information regarding waist circumference of children under the age of 11 was not available. In the United States, waist circumference data compiled from NHANES III was used to develop percentiles for children and adolescents aged 2-18 years (Fernandez, Redden, Pietrobelli, & Allison, 2004). Age, sex and ethnicity specific percentiles were estimated via percentile regression (Fernandez et al., 2004).

One of the major limitations for developing international and national reference data for optimal waist circumference measurements is the lack of consensus on the area where the measurement should be assessed. The NHANES III assessed waist circumference just above the uppermost lateral border of the right ilium, the 1981 Canada Fitness Survey measured at the noticeable narrowing of the waist, and the Heart & Stroke Foundation of Canada (2006) states that the measurement should be taken at the bottom of the ribs and the top of the iliac crest. In order to make comparisons amongst different populations and studies it is imperative that a consensus on the location of measurement is reached.

v. *Conclusion*

Although the means for measuring overweight and obesity mentioned above are available to identify individuals and populations at risk for disease, it is important to recognize the limitations of using these measures. The use of BMI can inappropriately classify individuals into weight categories; BMI does not distinguish differences in proportions of fat mass and fat free mass (Troiano & Flegal, 1999). Furthermore, cut-off points of 0.01 BMI units separate children classified as being normal weight from those classified as overweight, meaning that very small differences in BMI values will result in children being classified in different weight categories.

b. Obesity in Canadian Children & the Aboriginal Population

Over the past 45 years, there has been a trend in increased stature, body mass, weight-for-height, and the prevalence of overweight and obesity in Canada (Katzmarzyk, 2002). National trend data demonstrates a systematic increase in body mass for both boys and girls, starting in 1966 (Tremblay & Willms, 2000). Between 1981 and 1996 there was an average increase of 0.1 BMI units per year in children ages 7-13 (Tremblay & Willms, 2000). In 2004, 26% of Canadian children and adolescents aged 2 to 17 were classified as being overweight or obese; 8% were obese (overweight and obesity were classified using IOTF cut-offs) (Shields, 2005). Over the past 25 years, overweight in Canadian children and adolescents has doubled and obesity has tripled (Shields, 2005).

The obesity epidemic in Canadian Aboriginal children is even more apparent than in non-Aboriginal Canadian children. Obesity and other lifestyle-related chronic diseases disproportionately affect Canadian Aboriginal communities (Health Canada, 2003). In 2004, the reported overweight and obesity prevalence of young Canadian Aboriginals living off reserve was 41%, with 20% being classified as obese (Shields, 2005). Findings of the First Nations Regional Longitudinal Health Survey (2002-03) found that 22.3% of surveyed First Nations children living on reserve were overweight and 36.2% were obese using IOTF cut-offs (Cole et al., 2000).

In addition to national reports on the prevalence of overweight and obesity in Aboriginal children and adolescents, there have been various independent surveys reporting the prevalence of overweight and obesity in different Aboriginal communities in Canada. Bernard, Lavallee, Gray-Donald, & Delisle (1995) found a 38% prevalence rate of overweight among youth participants in two Cree communities in the James Bay Territory, using the 90th percentile of the NHANES II reference data. Boys and girls aged 2-19 years in Sandy Lake Ontario were found to have a 27.7% and 33.7% respective prevalence rate of overweight using the 85th percentile of the NHANES III reference date (Hanley et al., 2000). Mohawk children from the Kahnawake reserve near to Montreal had an overweight prevalence, using the 85th percentile of the NHANES II reference data, of 30% in boys and 33% for girls (Potvin et al., 1999).

One of the major limitations of these findings is that various reference populations were used to classify children as overweight or obese. When using different reference data, prevalence rates will change (Willows, Johnson, & Ball, in press; Flegal, Ogden, Wei, Kuczmarski, & Johnson, 2001). With a variety of methods of classification being used, it is difficult to monitor changes in prevalence rates of weight status over time, and to make comparisons among populations. Nevertheless, regardless of the mentioned limitations, it is evident that obesity is highly prevalent in Canadian children. It is also evident that Aboriginal children are at greater risk for having an above normal weight status.

c. Obesity in children is a health problem

Obesity can lead to a number of negative health outcomes. Its association with chronic disease and increased risk for morbidity and mortality are evident, in addition to the psychosocial consequences that accompany it. Children who are obese are predisposed to both immediate and future negative health consequences. Moreover, Aboriginal children appear to be at greater risk for the negative effects of obesity than non-Aboriginal children. The following will describe both the physical and psychosocial implications of childhood obesity.

Children who are obese tend to become obese adults (Dietz, 1998). The negative complications resulting from adult obesity have been well documented (Dietz, 1998). There are many consequences of obesity that become evident in childhood (Must & Strauss, 1999), including slipped capita femoral epiphysis, sleep apnea, pseudotumor cerebri and polycystic ovarian disease (Schonfeld-Warden & Warden, 1997; Must & Strauss, 1999). In addition, pediatricians are seeing an increased number of cases of hypertension, dyslipidemia, and type 2 diabetes in overweight and obese children (Hill & Trownbridge, 1998).

The metabolic syndrome is characterized by the clustering of metabolic abnormalities that are indicative of an increased risk for cardiovascular disease and all cause mortality (Moreno, 2002). The prevalence of the metabolic syndrome in youth is relatively low (3-4%); however, the prevalence among overweight or obese adolescents is markedly higher (over 25%) (Cruz & Goran, 2004). A high waist circumference appears to be a good predictor for the screening of the metabolic syndrome in both adults and children (Rodriguez, 2004, Esmaillzadeh et al., 2006). A study conducted by Maffeis, Grezzani, Pietrobelli, Provera, & Tato (2001a) demonstrated that a high waist circumference was significantly associated with plasma insulin, insulin resistance, and both diastolic and systolic blood pressure in a sample of children. In this study, girls in the highest quartile for waist circumference had more than a 20 times greater risk of being insulin resistant than the girls in the lowest quartile. An additional study performed by Maffeis, Pietrobelli, Grezzani, Provera, & Tato (2001b) found that there was a significant increase in metabolic risk factors in children with a waist circumference greater than the 90th percentile than those children below the 90th percentile. Moreover, results from the Bogalusa Heart study found that central adiposity measured by waist circumference in children was related to adverse concentrations of triacylglycerol, LDL cholesterol, HDL cholesterol, and insulin (Freedman, Serdula, Srinivasan, & Berenson, 1999a). In addition, children who were overweight had triglyceride levels 2.4 times higher, were 9.7 times as likely to have cardiovascular disease (CVD) risk factors, and were 43.5 times more likely to have three CVD risk factors than children who were not overweight or obese (Freedman, Dietz, Srinivasan, & Berenson, 1999b).

These studies indicate not only the risk of the metabolic syndrome in obese children but in particular in those children with a greater amount of visceral adiposity. It is therefore important to consider supplementing BMI with a waist circumference measure in order to measure both visceral adipose tissue as well as screening for the risk of metabolic syndrome, when evaluating the health of children.

One of the end results of the metabolic syndrome and metabolic abnormalities is type 2 diabetes. Type 2 diabetes was long thought to be an adult-onset disease that affected individuals of middle age and the elderly (Botero & Wolfsdorf, 2005). However, in the past few decades there has been a shift in the age of developing type 2 diabetes and it is now being identified in children. Risk factors for type 2 diabetes that have been identified for children are obesity, a family history of diabetes, elevated serum insulin levels, or blood sugar levels above normal (Cook & Hurley, 1998). Although there have been cases of type 2 diabetes in children of various ethnic backgrounds, this disease disproportionately affects children of ethnic minority, especially Aboriginal children (Botero & Wolfsdorf, 2005). The first diagnosis of the disease in Canadian children was in 1985 (Dean & Sellers, 2005). Although the total number of children presenting with type 2 diabetes remains relatively small, there is a growing consensus that the prevalence of type 2 diabetes in Aboriginal children will increase dramatically in the years to come (Dean, 1998). The increasing prevalence of type 2 diabetes among First Nations children is indicative of a major public health problem (Harris et al., 1996).

It has been suggested that the most immediate consequences of childhood obesity are in the psychological and social realms (Lobstein, Baur, Uauy, & IASO International Obesity Task Force, 2004; Dietz, 1998; Maffeis & Tato, 2001). Few problems have as significant an impact on emotional development in childhood as obesity (Must & Strauss, 1999). Middle childhood is a critical period for the development of both body image and self-esteem (Must & Strauss, 1999), and childhood obesity may compromise a child's healthy development. Discrimination against overweight and obese children begins early in childhood and continues to progress indefinitely through the stages of life (Dietz, 1998). Along with discrimination, there is the teasing and victimization of obese children (Must & Strauss, 1999). Unfortunately, the psychosocial impact of obesity on children is often disregarded while the physical consequences are stressed. It is therefore important to emphasize the need for attention to be placed on the emotional development of children who are overweight and obese and to try to dispel some of the negative connotations that adults and other children put on childhood obesity.

2.2 THE ETIOLOGY OF OBESITY

a. General Discussion

Obesity reflects a multifaceted interaction among genetic, metabolic, cultural, environmental, socioeconomic and behavioral factors (Morrill & Chinn, 2004; Schonfeld-Warden & Warden, 1997). Due to its rapid development in genetically stable populations, the obesity epidemic can be mainly attributed to environmental and behavioral factors affecting diet and physical activity levels (Pereira et al., 2005; Haire-Joshu & Nanney, 2002). Over the past few decades, various changes in our built environment have promoted sedentary lifestyles and low quality diets (Sallis & Glanz, 2006). The abundance of energy dense foods, high sugar and high fat foods, larger portion sizes, changes in the home food environment, increased sedentary activity and decreased physical activity and outdoor play are all contributing to the childhood obesity epidemic (Paxson, Donahue, Tracy Orleans, & Grisso, 2006; Lobstein et al, 2004).

Weight gain is caused by energy imbalance. There are a variety of factors that influence both energy intake and energy expenditure; meaning that there are a number of factors influencing the development of obesity. Energy that is consumed as food and is not expended through activity is stored as fat; therefore, regular physical activity to maintain energy balance in childhood is essential in the primary prevention of obesity (Harrell et al., 2003).

There have been marked changes in portion size, family meal patterns, and in the dietary composition of meals that children eat (Anderson & Butcher, 2006). Eating away from the home, and fast food and restaurant use, is rapidly becoming more common (French, Story, Neumark-Sztainer, Fulkerson, & Hannan, 2001). The most significant dietary trend since 1977 has been the shift in energy intake from the home to away-from home food sources (Nielsen, Siega-Riz, & Popkin, 2002). Between 1977 and 1996, the contribution of away from home food to the total diet almost doubled; 18% to 32% (Guthrie, Lin, & Frazao, 2002). The amount of calories per meal is greater in meals away from the home than home-prepared meals (Guthrie et al., 2002). Children may be at increased vulnerability to the high energy density of fast foods because they have not yet developed the essential cognitive restraint that enables an individual to remain lean in our modern day food environment (Prentice & Jebb, 2003). Most fast food restaurants inherently promote or induce passive over-consumption which can lead to weight gain (Prentice & Jebb, 2003). In addition, there are a variety of negative behavioral associations that accompany frequent fast food usage including increased television viewing; increased consumption of fat, energy and soft drinks; the consumption of fewer whole-grains, fruits and vegetables; and, less fiber (Astrup, 2005).

Concomitant with increases in fast-food intake, children are consuming more and more sweetened beverages such as fruit drinks and carbonated sodas. The mean consumption of carbonated beverages among school aged children has more than doubled in the past two decades (French et al., 2001). Troiano, Briefel, Carroll, & Bialostosky (2000) found that beverages contributed to 20-24% of energy across all children 2-19 years and soft drinks provided 8% of energy in adolescents. Soft drink consumers have a higher daily energy intake than non consumers at all ages (Murray et al., 2004). Carbonated beverages provide little or no nutritional value beyond calories and represent the largest contributor of added sugars in the diets of adolescents (Rampersaud, 2003).

Physical activity plays a significant role in preventing and treating obesity in addition to protecting against disease (Harrell et al., 2003). Tremblay & Willms (2003) found that Canadian children who were physically active were provided protection from overweight and obesity, while watching television and gaming were risk factors. Environmentally, there have been major recent changes that have likely influenced physical activity levels in children. Communities were formerly developed to support convenient pedestrian travel, where amenities were within walking distance of residential areas (Sallis & Glanz, 2006). With urban sprawl and the development of suburbs, communities are now less conducive to pedestrian travel (Sallis & Glanz, 2006; Anderson & Butcher, 2006). In the past, children played outside and walked to school, but now due to safety concerns and long distances to schools there are few children who engage in these activities (Sallis & Glanz, 2006). Changes in proxy measures of sedentary activity such as car ownership and television viewing closely pattern the rise in obesity (Prentice & Jebb, 1995). Children spend much more of their time engaging in screentime; at the computer, playing video games or watching television and videos (Anderson & Butcher, 2006).

The aforementioned environmental changes all have a role in the development of childhood obesity. It is their interaction with one another that is leading to the constant state of energy imbalance that is resulting in the obesity epidemic. Although the individual and behavioral role in the development of childhood obesity is acknowledged, changes in the environmental might be as important. Children do not always have the capacity to make informed decisions on what is healthful and what is not, therefore by improving their environmental surroundings it may make it easier for them to make healthful choices in terms of both physical activity and diet (Paxson et al., 2006).

b. The nutrition environment

Although food choices are often thought of as being at the individual level, there are many factors that mediate dietary intake. The community nutrition environment, organizational nutrition environment (home, school, work, other) and the consumer nutrition environment are all environmental variables that affect the nutrition environment as a whole (Glanz et al., 2005). The environmental influences on diet involve access to foods for home consumption from supermarkets and grocery stores and access to ready made foods for out of home and home consumption (restaurant/take-out foods) (Cummins & Macintyre, 2006). Price and availability are influential mediators of the nutrition environment (Glanz, Sallis, Saelens, & Frank, 2005). The availability and ease of access of energy dense snacks across the various environments that a child spends time in can influence the dietary intake and dietary quality of children (Haire-Joshu & Nanney, 2002). Studies in both the United States and Canada have found differences in the price and availability of foods in lower income neighbourhoods and communities; healthier foods generally are more expensive and less readily available (Cummins & Macintyre, 2006). It has been suggested that the nutrition environment helps to explain racial/ethnic and socioeconomic disparities in both nutrition and health outcomes (Glanz et al., 2005).

The home food environment is possibly the most complex and dynamic food environment (Glanz et al., 2005). The availability of foods in the home is affected by the availability of foods at food purchasing outlets and the amount and cost of healthy versus unhealthy options that are offered (Glanz et al., 2005). The physical environment in which a family resides can influence both the access and availability of food; from the foods that are available, parents can control what foods are offered and prepared in the home (Haire-Joshu & Nanney, 2002). Children are dependent on their parents to provide them with food, or with the monetary means to purchase their food, and the child's food environment is therefore constrained and shaped by the parents own food preferences and selections, which are determined by broader cultural and economical contexts, such as cost, convenience, taste and availability (Birch & Davison, 2001).

The availability of foods in the home, such as fruits and vegetables, has consistently shown a strong correlation with actual intake (Neumark-Sztainer, Hannan, Story, Croll, & Perry, 2003; Hanson, Neumark-Sztainer, Eisenberg, Story, &Wall, 2005; Davis et al., 2000; Haire-Joshu & Nanney, 2002; Bere & Kelpp, 2004; Cullen et al., 2003). However, as convenience has become a priority in many households, the home food environment has changed to include an increased amount of away from home (i.e., take-out) and pre-prepared foods (Anderson & Butcher, 2006). With children purchasing and consuming many more of their meals outside the home, examining the community environment as a whole rather than solely examining the home food environment may become a more relevant means of indirectly measuring dietary intake.

c. Dietary and Physical Activity Recommendations for children

Both dietary and physical activity guidelines for children have been put forth by Health Canada (Canada's Food Guide to Healthy Eating and Canada's Physical Activity Guide for Youth). In addition, recommendations for micronutrient intakes have been established by the Institute of Medicine's Dietary Reference Intakes (DRIs). These dietary and physical activity guidelines and recommendations allow for the current diets and physical activity levels of children to be assessed.

i. Dietary Recommendations

The composition of children's diets over the age of four years should be in agreement with Canada's Food Guide to Healthy Eating recommendations for the intake of the food groups (Canadian Pediatric Society, 2006). The Food Guide recommends that children daily consume 5 to 12 servings of grain products, 5 to 10 servings of fruits and vegetables, 2 to 3 servings of milk for children aged 4 to 9 and 3 to 4 servings for adolescents aged 10 to 16, and 2 to 3 servings of meat and meat alternatives (Health Canada, 1992). Dietary fat recommendations for children over the age of two years limit percent calories from fat to 30% of total energy intake and limit percent calories from saturated fat to 10% of total energy (Canadian Pediatric Society, 2006). In addition, food patterns that emphasize variety, complex carbohydrates and include lower fat choices are appropriate and desirable for children (Canadian Pediatric Society, 2006).

Recently, Canada and the United States collaborated with one another to establish nutrient reference levels that optimize health, prevent risk of chronic disease, and avoid deficiencies (Gibson, 2005). The DRIs were established to reduce the risk of chronic disease and degenerative disease, establish an upper level of intake designed to avoid risk of adverse health outcomes, and to include components of food not conventionally considered to be essential nutrients but which may have a possible health benefit (Gibson, 2005). The DRIs consist of four components: estimated average requirement (EAR), adequate intake (AI), recommended daily allowance (RDA), and tolerable upper intake level (UL) (Fitzgerald, 2002). The EAR is based on a specific criterion of adequacy, defined specifically by the biochemical measurement or function, which varies with the nutrient (Gibson, 2005). The UL describes the highest usual daily nutrient intake to pose no risk for adverse health effects for almost all individuals (Gibson, 2005). The RDA's are based on the EARs and are a value estimated to meet the requirements of 97 to 98% of individuals in a specific age and sex group (Gibson, 2005). Reaching or exceeding the AI denotes a low probability of inadequacy; AI's are used when the EARs are not defined for a specific nutrient (Gibson, 2005). It is important to note that DRIs do not have the ability to identify a single person as being at risk for inadequacy; the actual nutrient requirement of an individual is not known (Gibson, 2005). For this reason, a comparison of dietary intake with the DRI values can solely be used to assess the quality of the intake of a group (Fitzgerald, 2002). With a group of people, we can use the average intake in relation to the DRIs, which will then designate whether there is risk of inadequacy in the respective group.

ii. Physical Activity Recommendations

Canada's physical activity guide for youth emphasizes a gradual increase in the amount of time spent in physical activity over the course of several months (Health Canada, 2002). It states that children should begin by increasing their total time spent in physical activity by 30 minutes and gradually increase the time spent in physical activity each day (Health Canada, 2002). Concomitantly, children should begin by decreasing sedentary activity by 30 minutes each day (Heath Canada, 2002). Over the course of several months children should aspire to reach a goal of 90 minutes or more of physical activity per day in addition to a 90 minute, or more, per day decrease in sedentary activity or screentime (Health Canada, 2002). The physical activity performed should be a mixture of moderate and vigorous activity and should include activities that they enjoy (Health Canada, 2002). Children should engage in activities that involve endurance, strength, and flexibility (Health Canada, 2002).

Guidelines have recently been established as a reference for the minimum number of steps required to meet physical activity recommendations and maintain a BMI in the normal range. The Tudor-Locke recommendations are based upon an optimal step count that relates to healthy BMI values in a sample of 1954 children (Tudor-Locke et al., 2004a). One thousand steps are approximately equivalent to a child performing ten minutes of brisk walking (Tudor-Locke et al., 2004a). Tudor-Locke et al. (2004a) found that girls aged 6-12 years who took less than 12,000 steps/day and boys who took less than 15,000 steps/day were more likely to be classified as overweight or obese.

d. Validity, Reliability, Bias and Accuracy of Measurement Tools

When evaluating a specific research tool, it is important to clearly define the different criteria used for its assessment. Although we often use the notion of validity, reliability and accuracy interchangeably, they are distinct. Validity refers to the degree to which a test or an instrument measures what it intends to measure (Moons, Marquet, Budts, & De Geest, 2004). It measures the appropriateness, meaningfulness, and usefulness of the test or instrument in question (Jensen, 2003). Reliability refers to the extent to which the test or instrument is free from errors of measurement (Jensen, 2003), meaning that if the test is repeated the findings will remain the same. Accuracy refers to the degree of conformity of a measured or calculated value to its actual or specified value (Jensen, 2003); indicating the degree of precision of a test or evaluative tool.

Validity is often considered the most important consideration in the evaluation of measurement tools (Jensen, 2003); an evaluative tool can be both reliable and accurate without being valid. If the test is not evaluating what it intends to measure the results have no significance or use. When there is a predisposition to unfairly or un-objectively influence a given outcome, there is a bias. When looking at biases in dietary and physical activity information, it is important to consider the aforementioned meaning of validity, reliability and accuracy in order to better understand the ways in which these evaluative tools can be compromised.

e. Measurement tools

i. Measurement of dietary intake in children

Determining an individual or group's usual dietary intake is essential when the relationships between diet and biological parameters or chronic disease are being assessed (Gibson, 2005). Food frequency questionnaires, 24-hour recalls, and food records are the most commonly used and accepted measurement tools for evaluating dietary intake.

The food frequency questionnaire (FFQ) consists of the structured listing of individual foods or food groupings (FAO, 2005; Gibson, 2005). For each item on the food list, the respondent is required to estimate the regularity of consumption based on specific frequency categories which indicate the number of times the food is usually consumed per day, week, month or year (FAO, 2005). Food frequency questionnaires are designed to estimate a large number of nutrients and generally include between 50 and 150 food items (FAO, 2005). It is unlikely that children under the age of ten would provide reliable intake information on FFQ covering periods longer than one day; repeated 24-hour recalls may be a more feasible alternative (Livingstone et al., 2004).

Food records, or food diaries, are a method for measuring dietary intake in which the individual is responsible for recording all foods and beverages consumed for a specific time frame (FAO, 2005). The amounts of both food and beverages consumed are recorded as accurately as possible by estimating the total volumes or by physically weighing the food (FAO, 2005). A weighed food record is the most precise and accurate method available for estimating usual food and nutrient intakes at the individual level (Gibson, 2005). This method does not rely on memory and allows for a relatively easy means of quantifying amounts consumed which contributes to its acceptance as the gold standard of evaluative dietary protocols (FAO, 2005). Nevertheless, it does require a high level of participant burden, requires literacy, and most importantly, may alter intake behavior, which may contribute to its ineffectiveness in some populations (FAO, 2005).

The 24-hour dietary recall consists of the listing and quantification of foods and beverages consumed in the previous 24 hours. Foods and their respective amounts are recalled from memory with the aid of a trained interviewer (FAO, 2005). In this approach there is little respondent burden, no literacy requirement, and it is not likely to alter intake behavior (FAO, 2005). However, its weaknesses lie upon its reliance on the subject's memory, its requirement for a skilled interviewer, and the difficulty in estimating amounts consumed (FAO, 2005). Estimating the amount of food consumed is a complex cognitive task which, because of their developmental stage, may be additionally difficult for children (Livingstone & Robson, 2000). Common foods and main course items are more easily recalled than less common foods and snack items, although visual aids and non-directive prompts have been shown to be vital in gaining maximum recall of dietary intake (Livingstone, Robson, & Wallace, 2004).

Multiple repeated administrations of 24-hour recalls on non-consecutive days are required to estimate the habitual intake of children with acceptable precision (Stein, Shea, Basch, Contento, & Zybert, 1991). The inclusion of one weekend day may also prove to be beneficial, as weekend consumption has been shown to differ from weekday intake for some respondents and specific nutrients (Larkin, Metzer, & Guire, 1991).

When seeking dietary information from children, the level of literacy, lack of knowledge of foods, food measurement and food preparation, a lack of interest, as well as a shortened attention span may contribute to problems in obtaining reliable and valid information regarding their diets (Crawford, Obarzanek, Morrison, & Sabry, 1994). However, children between the ages of seven and nine have been shown to provide unbiased results when reporting their dietary intake (Goldberg et al., 1993). By the time that children reach seven to eight years of age, there is a rapid increase in their ability to participate in an unassisted recall, but solely for food eaten in the immediate past for durations no longer than 24 hours (Livingstone & Robson, 2000). By the age of eight to ten years children can reliably report their food intake, often as reliably as their parents (Livingstone et al., 2004). In addition, between the ages of seven and 12, the novelty and the added curiosity of assisting in the reporting of food intakes may help sustain enthusiasm and thereby compliance in dietary monitoring (Livingstone & Robson, 2000). By adolescence the additional demands of recording imposed by higher energy intakes, unstructured eating patterns, increased number of meals away from home, unease with body image and rebellion against authority may all contribute to poor compliance in dietary reporting (Livingstone & Robson, 2000).

Many of the methods of collecting dietary intake data have inherent errors and biases. Underreporting has beset attempts to report dietary intake. Incongruities in reported intake with actual intakes are difficult to identify and assess as intake can be highly variable within and between subjects. Reported food and energy intake may be biased by a number of factors including age, sex, education level, health consciousness, dieting and degree of obesity (Johansson, Solvoll, Bjorneboe, & Drevon, 1998). When examining the dietary intake of adolescents and children, there are differences in the degree of accuracy of results as children grow older. Bandini (1997) found that energy intake in children between the ages of seven and nine did not differ in comparison to energy expenditure, however in the 12 to 15 year old adolescents there was a significantly lower energy intake in comparison to energy expenditure. This finding is in agreement with previous studies that have shown that as age increases towards adolescence the degree of underreporting increases, thereby rendering the reported dietary intakes less accurate (Bandini, 1997). Although there are several reasons for the change in the accuracy of dietary recalls as children grow older, social influences, as well as lack of interest, may in part reflect the increased underreporting in adolescents in comparison to children.

iii. Measurement of the home food environment

Pantry studies are often used to examine the home food environment. These studies often use questionnaires to identify the availability of various foods in the home. Pantry studies represent the home food environment and do not directly measure actual individual intake (Bryant & Stevens, 2006). The rationale for using pantry studies is based on the evidence that the availability of food influences dietary intake (Bryant & Stevens, 2006).

The research study reported in this thesis used a questionnaire developed by Neumark-Sztainer et al. (2003) and later adapted by Hanson et al. (2005) for the Project Eating Among Teens (Project EAT) survey to assess the availability of fruits and vegetables, milk, soda, real fruit juice, and chips in the home, thereby describing the home food environment. Participants were asked, using a 4 point likert scale ranging from "never" to "always", whether they had access to the specified foods. A copy of the survey can be found in the Appendix. Findings from the Project EAT survey suggest that actual intake and the availability of the aforementioned foods in the home are correlated (Hanson et al., 2005). However, as more and more children consume their energy from foods away from the home the validity of using such home food environment surveys may be diminished as a proxy measure of the foods that children eat. If children are eating most of their meals outside the home, measuring the home food environment loses its importance and significance in terms of evaluating actual intake.

iv. *Measurement of Physical Activity & Fitness in children*

Physical activity is any bodily movement produced by skeletal muscle that results in energy expenditure (Nieman, 1999). Physical fitness refers to one's ability to perform daily tasks and physical activity (Nieman, 1999). Health related physical fitness includes cardiorespiratory endurance, body composition, flexibility and musculoskeletal fitness (Nieman, 1999). Many experts consider cardiorespiratory endurance to be the most important of the health related physical fitness components (Nieman, 1999).

Cardiorespiratory endurance is the ability to continue to persist in strenuous tasks involving large muscle groups and can be measured through the direct or indirect measurement of maximal oxygen uptake (VO_2 max) (Nieman, 1999). Although physical activity and physical fitness are often used interchangeably and are closely related, they are distinct. There is a positive relationship between physical activity and physical fitness in both adults and children when objective measures of assessing physical activity and fitness are used (Rowlands & Eston, 2004). Increasing the frequency, intensity and time spent in physical activity will result in increased overall fitness levels (Nieman, 1999). Nevertheless, it is important to note that the relationship between physical activity and physical fitness is a moderate relationship due to the influences of both genetics and maturation on individual fitness levels (Masurier & Corbin, 2006). Physical activity, which refers to movement, can be measured by motion sensor devices, while physical fitness is indirectly measured by a variety of sub maximal and maximal exercise tests.

- *Pedometers*

Pedometers are motion sensor devices that are often used to measure physical activity. Pedometers have an internal, horizontal, spring-suspended lever arm that moves during regular walking movements (Tudor-Locke, 2003). Each time a movement is made at the hip, an electrical circuit closes and a step is recorded (Tudor-Locke, 2003). In order to ensure the best accuracy of measurement, pedometers should be placed on the midline of the thigh and secured to avoid unintentional re-setting of the device. Pedometers are inexpensive and have been validated for measuring physical activity in children (Rowlands & Eston, 2004). Pedometers have been shown to have moderate to high correlations with various objective measures of physical activity: accelerometers, behavioral observation and heart rate monitoring (Beets, Patton, & Edwards, 2005; Rowlands & Eston, 2004; Tudor-Locke, Williams, Reis, & Pluto, 2004b). Four days of pedometer monitoring is an acceptable length of time to determine habitual activity levels in children (Tudor-Locke et al., 2004a; Vincent & Pangrazi, 2002).

There are several drawbacks of the use of pedometers for measuring physical activity in children. Pedometers are unable to accurately account for vigorous physical activity and are incapable of accounting for energy expenditure due to increases in stride length (Rowland & Eston, 2004). Pedometers do not detect non-weight bearing activities, cannot be worn during water sports, and do not account for more complex and upper body movement patterns often seen in children (Tudor-Locke et al., 2004a). Moreover, pedometers measure total steps accumulated and do not account for the varying intensities of physical activity (Rowlands & Eston, 2004). For example, a study by Rowlands & Eston (2004) found that all children who met or exceeded the Tudor-Locke recommendations also met United States physical activity guidelines of 60 minutes or more per day. However, nearly half of boys and a small proportion of girls performed 60 minutes or more of physical activity but did not meet the Tudor-Locke step recommendations. Furthermore, it has been suggested that excessive abdominal adiposity may interfere with accurate pedometer readings via inappropriate placement of the device or perhaps by dampening the force of vertical accelerations (Tudor-Locke, Williams, Reis, & Pluto, 2002). Shepherd, Toloza, McClung, & Schmalzried (1999) found that the degree of measurement error in terms of step counts was positively correlated with BMI ($r = 0.79$).

In conclusion, pedometers are an acceptable means of measuring physical activity; however, their limitations must be acknowledged and considered when employing their use.

- *20-meter shuttle run test (20 MST)*

The 20 MST is a maximal, volitional running test that indirectly measures VO_2 max. VO_2 max is the maximal volume of oxygen that the body can consume when engaging in intense, whole body exercise (Nieman, 1999). Oxygen consumption is linearly related to energy expenditure, therefore when we are describing oxygen consumption we are indirectly measuring an individual's maximal capacity to do work; in other words, their degree of physical fitness (Nieman, 1999). Therefore, the legitimacy of using the 20 MST to predict VO_2 max is based on the assumption that maximal work is reached at the end of the run (Leger & Lambert, 1982).

The 20 MST begins at a speed of 8 kilometers per hour, and progressively increases each minute to the sound of an audio signal (Leger & Lambert, 1982). The subjects run back and forth between two marked lines, which are 20 meters apart, until exhaustion (Leger & Lambert, 1982). The subjects' last shuttle run stage completed is recorded and put into an equation to derive their predicted VO_2 max (Leger & Lambert, 1982). Leger, Mercier, Gadoury, & Lambert (1988) developed prediction equations to convert 20 MST scores to VO_2 max for children and adolescents 8-19 years old. No significant differences were found between measured peak VO_2 max and that derived from the 20 MST when the last stage completed was entered into the prediction equation (Leger et al., 1988). The 20 MST is therefore a valid means of measuring physical fitness of both children and adults and it is a feasible means of classifying physical fitness levels.

Since the early 1980's the 20 MST has often been used to assess the aerobic physical fitness of both children and adults and has consistently shown high reliability and validity (Tomkinson, Leger, Olds, & Cazorla, 2003; Beets & Pitetti, 2004). Test and re-test studies have confirmed the shuttle run's high degree of reliability (r= 0.975) (Leger & Lambert, 1982). However, there are limitations of the test such as running efficiency, anaerobic capacity, motivation and social dynamics, which all have the potential to result in decreased 20 MST accuracy when classifying individuals into different fitness categories (Tomkinson et al., 2003). It is therefore important to recognize these limitations and attempt to limit their influence on the test as much as possible.

f. Diet, Physical Activity, Sedentary Behavior and Childhood obesity

There are several studies that describe the relationship among lifestyle factors and overweight and obesity among children. The following studies are comprehensive in nature and describe and analyze several of the factors associated with childhood weight status.

The Canadian Community Health Survey (CCHS) (Shields, 2005) was a survey conducted on a nationally representative sample of 8,661 Canadian youth aged 2-17 years. Measured heights and weights, a FFQ measuring the intake of fruits and vegetables, and separate questionnaires for physical activity and screentime were administered to the sample. Analysis of the CCHS data (Shields, 2005) found that children who consumed more fruits and vegetables were less likely to be overweight or obese than children who consumed fewer fruits and vegetables. Children aged 6-11y and adolescents aged 12-17y had a decreased probability of being overweight if they engaged in a lower number of screentime hours per day. In boys aged 12-17y there was a negative relationship between physical activity and overweight and obesity.

The major strength of the CCHS is its large sample and its representation of the Canadian child and adolescent population. Although questionnaires are not the best means of acquiring dietary, physical activity, and screentime information, the large sample size made it far too arduous to use more objective methodologies. A strength of this survey was its use of measured heights and weights rather than self-reported measures. In large samples, height and weight measurements are often compromised by using self-reports; these may differ from actual heights and weights making it difficult to accurately classify children as overweight (Strauss, 1999).

A study examining the influence of diet, physical activity and sedentary behaviors as risk factors for overweight in adolescents was performed by Patrick et al. (2004). A total of 878 adolescents aged 11-15 years, of which 42% were from minority backgrounds, were included in the study. CDC growth charts were used to classify children as being at risk of overweight (above 85th percentile) or overweight (above 95th percentile). Physical activity was measured with accelerometers, a self-reported validated questionnaire measured sedentary behavior, and three 24-hour dietary recalls on non-consecutive days, including one weekend day, were used to measure dietary intake.

Interestingly, adolescents who were classified as being at risk of overweight or those who were overweight consumed significantly fewer calories than adolescents in the normal body weight classification. As compared to normal weight children, children who were at risk of being overweight or those who were overweight engaged in significantly fewer minutes of vigorous activity per day, consumed significantly less fiber, and boys in these weight classifications performed less moderate physical activity and engaged in more sedentary activity. In addition, failing to meet the 60 minutes per day of moderate to vigorous activity recommendations was associated with being at risk of being overweight and being overweight.

The methodology used in this study provided important information in terms of the roles that physical activity and diet have on weight status. The major strengths of this study were the use of three 24-hour recalls, as well as using accelerometers to measure physical activity. Accelerometers have the ability to measure the intensity of activity, which is not possible with pedometers (Rowland & Eston, 2004). This information provided an explanation for the findings of lower caloric intake in the overweight adolescents (ie, normal weight children were more active). With information regarding the intensity of activity that adolescents are performing, assumptions could be made regarding their energy expenditure and their required energy intake. This study was both comprehensive and informative with a solid methodological protocol.

There has been a proposed association between children's weight status and the home food environment, in addition to other lifestyle factors. Gable & Lutz (2000) completed a study that described the home food environment in relation to obesity in 65 children aged 6-10 years. In this study, parents completed household characteristics and home food availability surveys as well as a FFQ reporting the dietary intake of their participating child. Parents were also asked questions regarding the amount of time children spent in play and the number of hours per day spent watching television.

Children were classified as being obese or non-obese by means of BMI using IOTF cut-offs.

Parents who reported more family meals also reported more fruits and vegetables available in the home. Parents who reported a greater availability of sweets in the home also reported that their child ate more of these foods. Additionally, the availability of chips and salty snacks in the home was positively associated with the child's intake of high-energy density foods of low nutritional quality. There were no significant differences in the foods available in the home between the obese and non-obese children. Moreover, there were no significant differences in the actual dietary intakes between the non-obese and obese children measured through the FFQ. However, obese children engaged in significantly fewer hours of play and spent more time watching television than the non-obese children. More specifically, for each additional hour of television watched per day, the odds of becoming obese increased by 3.27. These results indicate that although there was no difference in the home food environment between obese and non-obese children, there was a large significant difference in the energy expenditure of these children indicated by both sedentary activity and physical activity.

Hanley et al. (2000) conducted a study in Sandy Lake, Ontario with Aboriginal children and adolescents aged 10-19 years. Information on diet, television viewing and physical fitness were obtained from 242 youth. Dietary information was obtained through the use of a FFQ and a single 24-hour dietary recall. Television viewing was measured through questionnaires and physical fitness was measured by means of a validated sub-maximal step test.

The prevalence of overweight was defined as being above the 85th percentile of the NHANES III reference data; 27.7% of boys and 33.7% of girls were classified as being overweight. Youth who engaged in more than five hours of television viewing per day had a significantly higher risk of obesity than those who watched two hours or less of television per day. Subjects with the highest fitness levels had a decreased risk of being overweight. Increased fiber intake was associated with a lower risk of being overweight; there were no other differences between weight classification and macronutrient composition. There were no significant associations between weight status and type of foods consumed.

This study demonstrates the interaction of diet, physical fitness and sedentary activity and their influence on obesity. One of the main strengths of this study was its comprehensive design which included information on various lifestyle factors. However, this study failed to measure physical activity. By measuring physical fitness, as a proxy measure of physical activity, information regarding energy expenditure is not obtained. Low levels of physical activity have been identified as a more important risk factor for excess weight gain then any dietary component (Prentice & Jebb, 1995), making it important to include an objective form of physical activity monitoring in comprehensive obesity studies such as this. Another weakness of this study was its use of the FFQ and a single 24-hour dietary recall for the measurement of dietary intake. FFQ are not appropriate for use with children, as they have trouble recalling foods consumed more than 24 hours previous (Livingstone et al., 2004). Moreover, a single 24-hour recall does not account for the day to day variability that an individual has in their diet.

Bernard et al. (1995) conducted a similar study in two Cree communities in the James Bay Territory of Northern Quebec. The objectives of the study were to analyze the diet of Cree children and adolescents, determine how diet was related to weight status, and to assess the relationship of weight to physical activity and sedentary behavior. A single 24-hour recall and questionnaires on both physical activity and television viewing were administered to the children. 144 children and adolescents in grades 4 and 5 and grades 8 and 9 participated in the study. On average, the children aged 9 to 11 years met or exceeded the recommended servings from each food group. In the adolescents over the age of 12, milk products and fruits and vegetables were below the recommended dietary intakes. Overweight subjects consumed significantly fewer servings of milk products and fruits and vegetables than children of normal body weight. Physical activity, of at least 30 minutes at an intensity that resulted in the child being out of breath, varied between 0 and 7 times per week with a mean of 2.7 times per week; younger children being the most active. Overweight children participated in less physical activity and spent more time watching television than non overweight subjects.

Overall this study was very thorough and complete. However, methodological limitations of this study were apparent, and in particular included the use of questionnaires for measuring physical activity and the use of a single 24-hour dietary recall. The use of questionnaires for the measurement of physical activity may result in biased results, as participants may intentionally or unintentionally report their activity levels inaccurately. It is therefore preferable to use objective means of evaluating physical activity such as motion sensor devices or observational records.

The Kahnawake Schools Diabetes Prevention Program (KSDPP) was a comprehensive primary prevention program for Mohawk children in Kahnawake, Quebec (Macauley et al., 1997). The KSDPP measured obesity, physical fitness, dietary intake, sedentary behavior and physical activity levels of children in grades 4-6. Subscapular skinfold thickness was used to measure adiposity, a 1 mile run/walk was used to evaluate physical fitness, a self-reported questionnaire was used to evaluate physical activity and sedentary behavior, and a FFQ (Macauley et al., 1997) in addition to a single 24-hour dietary recall was used to evaluate dietary intake (Trifonopoulos, Kuhnlein, & Receveur, 1998).

Analyzing the KSDPP data, Horn, Paradis, Potvin, Macaulay, & Desrosiers (2001) reported correlates and predictors of adiposity, assessed by subscapular skinfold thickness. Among girls, poor fitness, excessive television viewing, physical activity and involvement in community and summer sports correlated positively with higher subscapular skinfold thickness. Among boys, poor fitness, involvement in summer sports, and not playing outside was associated with higher skinfold thickness. Television viewing was the strongest correlate of skinfold thickness in girls; girls who watched six or more programs per week had skinfold thickness 30 percent higher than girls who watched less television. Interestingly, there was a positive relationship with involvement in community sports and physical activity and adiposity; however no plausible explanation for this association was provided.

One of the limitations of the KSDPP was its use of self-reported questionnaires for both physical activity and physical fitness and the use of a single 24-hour dietary recall. An additional limitation of the study is that the two-site skinfold test (subscapular and triceps or medial calf and triceps) should be used to measure adiposity in children (Nieman, 1999), yet the KSDPP used only the subscapular skinfold site to assess adiposity. Moreover, dietary information was not examined in relation to adiposity (Horn et al., 2001). It is therefore difficult to explain relationships between physical activity and adiposity, as energy intake was not reported in relation to adiposity.

i. Conclusion

There are various reasons why some studies fail to find significant relationships among physical activity, dietary intake and childhood overweight and obesity. Methodological issues such as self-report questionnaires to assess physical activity or the use of a single 24-hour dietary recall or a FFQ to gather dietary information may result in the lack of associations. Dietary information is riddled with error as it relies on the memory of the individual and the accuracy of their account of intake. Under-reporting and over-reporting are inherent potential biases of dietary reporting. Additionally, some studies do not account for physical activity or obtain subjective information that may also contribute to the lack of association between physical activity and overweight. Since weight gain results from energy imbalance, solely looking at one side of the energy equation is not the most appropriate means to evaluate risk factors for obesity.

Interestingly, sedentary behavior has consistently shown a positive relationship with overweight and obesity. Sedentary activities such as watching television and gaming appear to show a stronger relationship to weight gain in longitudinal studies than self-reported measures of physical activity (Slyper, 2004). It has been speculated that television viewing is one of the most easily modifiable causes of obesity among children (Robinson, 1999). However, the reason for this association is not clear. There have been two major theories to explain the association of television viewing with obesity: reduced energy expenditure from the displacement of physical activity or increased dietary energy intake, either during viewing or due to the exposure to food advertisements (Robinson, 1999). With increased screentime, there is the possibility for increased energy intake from snacking (Crespo et al., 2001; Anderson & Butcher, 2006), which will only contribute more to the incongruity in energy balance. Perhaps, because television viewing increases energy intake at the same time as decreasing energy expenditure, working on both sides of the energy balance equation, it has a greater association with overweight and obesity than physical activity. Although the risk factors for obesity have been agreed upon, there are many associations and lack of associations among lifestyle factors and overweight that remains unclear.

2.3 RESEARCH GAPS IN ABORIGINAL RESEARCH

There has not been enough research focus on the unique health needs of Aboriginal women and children (Young, 2003). Little is known about the availability of foods in the homes of children, dietary intake, physical activity and fitness levels of Aboriginal children. There are however, a growing number of studies that indicate that Aboriginal children are at high risk of being overweight or obese. Nevertheless, the causes of obesity are less well understood. It is important that Aboriginal research focuses on the reasons for the existence of health problems and disparities and possible solutions for their elimination (Young, 2003).

The research project reported in this thesis addresses some research gaps by examining a number of lifestyle factors that have been associated with childhood obesity. Previous studies in Canada that have described the dietary intake of Aboriginal children have solely used a single 24-hour recall for their dietary intake methodology. Consequently, the dietary information that was obtained may be incomplete and unable to describe dietary intake at the individual level. This research project addressed this limitation by administering three 24-hour recalls with the children on non-consecutive days, including one weekend day. In addition, children were asked about their home food environment and if the food that they ate was home-cooked or from restaurant or take-out.

Physical activity levels have often been assessed in Aboriginal children by self-reported questionnaires. Children may lack the developmental capacity to accurately assess their own physical activity levels in questionnaires (Welk & Corbin, 2000). For this reason, we used pedometers as an objective means of measuring physical activity. Moreover, we were able to predict physical fitness levels through the administration of the 20 MST. By thoroughly describing the various factors associated with obesity, we obtained information that will be useful in the development of interventions to address obesity in Cree children in Quebec. The information obtained from the research project can be applied to the development of culturally sensitive interventions for the children of the James Bay Territory.

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3. OBESITY, DIET, PHYSICAL ACTIVITY AND FITNESS IN CREE CHILDREN

3.1 INTRODUCTION

Obesity has reached epidemic proportions in many countries, including Canada (Kumanyika, Jeffrey, Morabia, Ritenbaugh, & Antipatis, 2002). Minority and ethnic groups, in particular, have high rates of obesity in developed countries (Kumanyika, 2004). Over the past 25 years, overweight in Canadian children and adolescents has doubled and obesity has tripled (Shields, 2005). In 2004, 18% of Canadian children and adolescents aged 2 to 17 who participated in the Canadian Community Health Survey (CCHS) were overweight while 8% were obese. Of participating Aboriginal children, all whom lived off reserve, 21% were overweight and 20% were obese (Shields, 2005). Findings of the First Nations Regional Longitudinal Health Survey (RHS) (2002-03), based on parent reported data, found that 22.3% of surveyed First Nations children living on reserve were overweight and 36.2% were obese. Similarly, a high prevalence of overweight and obesity has been observed among American Indian children in the United States (Story et al., 2003).

Obesity reflects a multifaceted interaction among genetic, behavioral, and environmental factors (Morrill & Chinn, 2004; Schonfeld-Warden & Warden, 1997). Due to its rapid development in genetically stable populations, the obesity epidemic can be mainly attributed to both environmental and behavioral factors affecting diet and physical activity levels (Pereira et al., 2005; Haire-Joshu, 2002). The current high rates of obesity are considered to be the result of increased consumption of high-fat, energy-dense foods simultaneous with declines in spontaneous and work-related physical activity over the past few decades (Hill & Trowbridge, 1998). For Aboriginal populations, the high rates of obesity may be explained by the transition from traditional diets and lifestyles to market foods of low nutritional quality in conjunction with decreased physical activity (Kuhnlein et al., 2003). The need for environmental-level lifestyle changes to decrease obesity prevalence in Aboriginal communities is therefore necessary in consideration of environments with an overabundance of food and limited opportunities to be physically active (Kumanyika, 2001).

The Cree are First Nations with widespread distribution throughout Canada and the United States (http://www.crystalinks.com/cree.html). To understand lifestyle factors associated with obesity in Cree children living in the province of Quebec, a study was undertaken to 1) identify the prevalence of pediatric overweight and obesity using measured heights and weights and 2) objectively describe behavioral risk factors. Dietary intake was recorded using three 24-hour dietary recalls, physical activity using pedometers, and physical fitness using the 20-metre shuttle run test.

3.2 SUBJECTS & METHODS

The Emiyuu Ayayaachiit Awaash Project (The Active Kids Project) was a study of children's diets, activity levels, physical fitness and weight status that was conducted in two schools in two Cree communities in the subartic region of northern Quebec. One community was rural with a population of approximately 3,500 people. The other community was remote and had a population of approximately 2,000 people. Market foods sold in community grocery stores were often costly (Willows, Iserhoff, Napash, Leclerc, & Verrall, 2005). The schools did not have meal programs and all children ate breakfast and lunch away from school.

All students who regularly attended grades 4-6 were eligible to participate. Prior to the commencement of the study, students were given information sheets and parental consent forms (Appendix), researchers met with school and Cree Health Board staff to discuss the study, and radio announcements were broadcast in each community to inform community members about the study.

a. Weight Status

To document children's weight status, body mass index (BMI) was calculated from children's measured heights and weights (Ng, Marshall, & Willows, 2006). Researchers were trained in the proper techniques to perform anthropometric measurements by an Exercise Scientist to ensure accuracy of measurement. Weight was measured to the nearest pound on a Health-O-Meter Professional Scale, Model HAP 300-01. Pounds were converted to kilograms using a conversion factor of 2.2. Children were asked to remove any bulky clothing and their shoes to ensure the accuracy of the weight measurement. Height was taken with the children's shoes removed. A set square was placed on the top of the child's head and children stood erect with weight equally distributed between both feet. Children were asked to take a deep inhalation and to hold their breath; at this point the height measurement was taken. Height was measured to the nearest tenth of a centimeter. International Obesity Task Force Cut-Offs were used to categorize children as normal weight, overweight, or obese (Cole, Bellizzi, Flegal, & Dietz, 2000).

Waist circumference was measured to the nearest tenth of a centimeter with an inelastic measuring tape. Waist circumference was measured at the smallest circumference below the rib cage and above the umbilicus when the child was standing with their abdominal muscles relaxed. In the case where there was no visible natural waist the measurement was performed at the level of the umbilicus. The child was asked to take a deep inhalation followed by a deep exhalation; at this point the measurement was taken. Waist circumference measurements were compared to the Third National Health and Nutrition Examination Survey (NHANES) age and sex specific reference data. If children exceeded the 85th percentile of the reference data they were considered to have abdominal obesity.

b. Physical Activity and Fitness

Students wore pedometers on two days to assess physical activity levels (Ng et al., 2006). Tudor-Locke's recommendations (Tudor-Locke et al., 2004) were used to ascertain if children met criterion-referenced standards for physical activity related to healthy body composition. Boys who took 15,000 or more steps and girls who took 12,000 or more steps per day met pedometer steps/day cut-points related to healthy body composition. Students completed the Leger 20-meter shuttle run test (Leger, Lambert, Goulet, Rowan, & Dinelle, 1984) during physical education class to assess physical fitness levels (Ng et al., 2006). To assess physical fitness levels, shuttle run times and the last shuttle run stage completed were recorded and compared to normative data from Quebec schoolchildren (Leger et al., 1984).

c. Dietary Intake

To measure dietary intake, three 24-hour dietary recalls were completed with each child on non-consecutive days, including one weekend day. Verbal probes, pictures and examples of foods available locally, and food models were used to obtain detailed information regarding food and drinks consumed, as well as quantities and methods of preparation. A multiple-pass dietary interview method was performed when conducting 24-hour recalls (Gibson, 2005; Arnold, 2006). Children spoke Cree as their mother tongue, with English as their second language. In the remote community where Cree was more predominant, a Cree translator was present to aid children who had difficulties speaking or understanding English.

Dietary information from 24-hour recalls was entered into Food Processor SQL for Windows (Food Processor SQL, Esha Research, Salem, Oregon). The Canadian nutrient file was used to better reflect the nutrient composition of foods and beverages consumed by children. Caloric intakes per kilogram body weight (kcal/kg) were determined by dividing a child's total calories averaged over the 3 days by their weight in kilograms. Sweetened beverages were considered non-diet soda pop, powdered fruit drinks, sports drinks and other drinks with added sugars. Fruits and vegetables were reported as the absolute number of fruits and vegetables consumed (excluding french fries and fruit juices), and as number of USDA servings of fruits (including 100% fruit juice) and vegetables (including french fries) (USDA, 1992). Given low fiber intakes, fiber intake was categorized as being equal to or above and below the 75th percentile of fiber intake of the sample population. Milk intake was categorized as having met or not met an average of 2 servings of milk per day (Health Canada, 1992).

The top 10 food contributing to calories and calories from fat were calculated by the summation of all calories and calories from fat contributed by a specific food or category, dividing the total number of calories and calories from fat from each food or category by the total calories and calories from fat consumed for all foods, and multiplying the fraction by 100 to get percent calories and percent fat calories from each food or category. The process was repeated for separate weight categories.

d. Statistical Analysis

Statistical analyses were performed using SPSS for Windows version 14.0. T-test and ANOVA (p-value <0.05) were used to assess group differences for continuous variables. The Bonferroni statistic was used to determine differences among groups. Pearson correlations were used to assess relationships between two continuous variables. The Chi-Square statistic was used to test group differences involving categorical data and to calculate unadjusted odds ratios.

e. Ethics

The study was approved by the Human Ethics Research Board, Faculty of Agriculture, Forestry, and Home Economics, University of Alberta. The Cree Board of Health and Social Services of James Bay and the school Principal in each community also approved the study.

3.3 RESULTS

Two hundred and twenty five students were eligible to participate; 208 received parental consent and 178 had complete dietary, anthropometric, physical activity and physical fitness data (participation rate 79%). Children had high rates of overweight (30.3%) and obesity (34.8%). Descriptive differences among weight categories are shown in table 3-1. Shuttle run time declined with increasing weight status, implying decreased fitness for children who were overweight and obese. Ninety seven percent of obese children, 87% of overweight children and 66% of normal weight children had very poor fitness levels. Obese children took the least number of steps. Sixty one percent of normal weight, 81% of overweight and 46% of obese boys met step recommendations (p=.051). Seventy two percent of normal weight, 55% of overweight, and 47% of obese girls met step recommendations (p=.117). Overweight children consumed fewer calories than normal weight and obese children; however, calories per kilogram were significantly higher among normal weight children than for overweight and obese children (p<.0001).

Overweight children consumed significantly less fiber than other children. Obese children had significantly lower intakes of milk, vitamin A and vitamin D than normal weight and overweight children. Forty five percent of normal weight, 44% of overweight and 48% of obese children exceeded 30% of calories from fat (p=.899). Normal weight, overweight and obese children slightly exceeded saturated fat intakes of 10 percent or fewer calories from saturated fat. There was a significant (p=.021) negative correlation between milk intake and sweetened beverage intake; however, the relationship was weak (r=-.172).

Waist circumference increased as weight status increased (table 3-2). Approximately half (52%) of children had truncal adiposity based on a waist circumference that exceeded the 85th percentile of the NHANES reference. Whereas 1.6% of normal weight children had a high waist circumference, 53.7% of overweight and 100% of obese children had a high waist circumference.

Table 3-3 shows the correlation between shuttle run times and pedometer steps by weight status. Shuttle run times and pedometer steps were weakly, but significantly and positively correlated (r=.310). The correlation was strongest for normal weight children and non-significant for obese children. Shuttle run times and pedometer steps were both significantly and negatively correlated with body weight; $r = -.438$ and $r = -.180$, respectively ($p<0.05$).

The top ten foods contributing to calories and calories from fat in the diet are shown in table 3-4. Of the top ten foods contributing to energy, seven were also among the top ten contributors to fat. Three foods (snack foods, milk and poutine) were among the top five contributors to both categories. For all weight categories, sweetened drinks contributed the most to energy. There was little variability among weight categories with respect to the relative rankings of foods contributing to energy and fat.

Sixty one percent of children consumed fewer than 5 USDA food guide pyramid servings of fruits and vegetables per day. Moreover, 83.7% of children consumed fewer than 3 total fruits and vegetables per day. Only two children consumed 5 or more fruits and vegetables per day. Few children met recommendations for milk intake; 19.1% of children consumed 2 or more servings of milk per day and of these children, 5.6% consumed 3 or more servings of milk per day.

Unadjusted odds ratios for lifestyle factors associated with overweight/obesity are shown in table 3-5. Consuming two or more servings of milk per day, being above the 75th percentile for fiber consumption, and consuming 5 or more USDA food pyramid servings of fruits and vegetables per day was associated with lower odds of overweight/obesity. A greater number of overweight/obese children than normal weight children consumed fewer than 5 USDA food guide pyramid servings of fruits and vegetables (table 3-6), consumed fewer than 2 servings of milk per day (table 3-7), and were below the 75th percentile for fiber consumption (table 3-8).

3.4 DISCUSSION

In recent history, Aboriginal people have had a poorer health status than other Canadians (Health Canada, 2003). Infectious disease, injuries, suicide, heart disease and diabetes disproportionately affect Aboriginal people (Health Canada, 2003). A high prevalence of overweight and obesity in First Nations and American Indian children has been previously reported in national surveys and small community based studies (Willows, 2005a, Shields, 2005; RHS, 2002-03; Story et al., 2003). This study of Cree living in communities in northern Quebec corroborates previous findings of extreme rates of overweight and obesity in Aboriginal children. Almost two thirds of children were overweight (30.3%) or obese (34.8%). Obese children were significantly taller than normal weight and overweight children likely due to early maturation associated with adiposity considering the three groups were similar in age (Dietz, 1998). Moreover, 77.6% of overweight and obese children had central adiposity, whereas very few children classified as having normal body weight had a high waist circumference. This finding of high waist circumference coupled with excess weight is disconcerting as central adiposity in children has been associated with metabolic abnormalities and the metabolic syndrome (Rodriguez, 2004; Esmaillzadeh, Mirmiran, & Azizi, 2006; Maffeis, Pietrobelli, Provera, & Tato, 2001a; Maffeis, Grezzani, Pietrobelli, Provera, & Tato, 2001b; Freedman, Serdula, Srinivasan, & Berenson, 1999).

Normal weight children had a significantly higher caloric intake than overweight children and normal weight children had a significantly higher caloric intake per kilogram body weight than both overweight and obese children, and were the most fit based on shuttle run times. Patrick et al. (2004) found similar results in a sample of 878 adolescents aged 11 to 15. Adolescents who were at risk for overweight or who were overweight consumed significantly fewer calories than normal weight adolescents. However, normal weight adolescents engaged in significantly more vigorous physical activity, assessed with accelerometers. The higher caloric intake of the normal weight children, adjusted for body weight, was perhaps explained by a higher intensity level of physical activity counterbalancing the increased energy intake. Although our study did not assess the intensity of physical activity, total physical activity was measured with pedometers, which indicated that obese children took the least steps. Ruiz et al. (2006) recently reported that vigorous physical activity was associated with lower body fat whereas moderate and total physical activity levels were not. Unfortunately, pedometers are unable to account for the intensity of activity. We can speculate since there were no differences in the number of steps taken per day between normal weight and overweight children, that there might have been a difference in the intensity at which those steps were taken, given the higher caloric intake and higher fitness levels in normal weight children.

Fitness levels were low among the Cree children in our study. Eighty three percent of children scored at or below the 20th percentile of reference data from a sample of sex- and age-matched Quebec schoolchildren (Leger et al., 1984). Poor fitness levels in First Nations children have been previously reported (Horn, Paradis, Potvin, Macaulay, & Desrosiers, 2001). Findings from the Kahanawake Schools Diabetes Prevention Program suggested low fitness levels among Mohawk children; 73.8% of girls and 62.5% of boys did not have satisfactory times in the run/walk test when compared to sex and age specific reference standards (Horn et al., 2001). We found a significant relationship among weight status and fitness scores. The degree of body fatness has previously been shown to be a strong predictor of fitness endurance (Rowlands, Eston, & Ingledew, 1999). Hanley et al. (2000) reported that Sandy Lake First Nations children in the third and fourth fitness quartiles had a significantly lower risk of overweight than children in the first (lowest) fitness quartile.

There is a positive relationship between physical activity and physical fitness of children when objective measures of assessing physical activity and fitness are used (Rowlands & Eston, 2004). Only a weak positive correlation between physical activity and physical fitness was observed in Cree children. Rowlands et al. (1999) reported moderate to high correlations (r=0.66) between fitness and physical activity measured with an accelerometer, and moderate correlations between fitness and physical activity measured with pedometers (r=0.59). Whereas accelerometers measure the intensity of activity, pedometers do not. It is possible that we did not see a strong positive relationship between fitness and pedometer steps because we did not account for the intensity of the exercise.

It is important to note the possibility of underreporting dietary intake in overweight and obese children. In adults, overweight and obese individuals are more likely to underreport their dietary intake than normal weight individuals (Johansson, Solvoll, Bjorneboe, & Drevon, 1998); however this relationship is not as evident in children. By the age of eight to ten years children can reliably report their food intake, often as reliably as their parents (Livingstone, Robson, & Wallace, 2004). In addition, between the ages of seven and 12, the novelty and the added curiosity of assisting in the reporting of food intakes may help sustain enthusiasm and thereby compliance in dietary monitoring (Livingstone & Robson, 2000). However, as age increases towards adolescence the degree of underreporting increases, thereby rendering the reported dietary intakes less accurate (Bandini, 1997). These findings suggest that the differences in caloric intake in the children of our study are not likely to be the result of underreporting, given their young age.

Higher intakes of fruits and vegetables, fiber and milk have all been associated with healthy body weights in children (Patrick et al., 2004: Shields, 2005; Barba, Troiano, Russo, Venezia, & Siani, 2005; Skinner, Bounds, Carruth, & Ziegler, 2003; Carruth & Skinner, 2001). However, consistent differences have not always been reported across different studies and there is limited information examining dietary intake and weight status in children (Huang, Howarth, Lin, Roberts, & McCrory, 2004). Moreover, differences in the dietary intake of children of different weight status have been seldom identified in Aboriginal children. Bernard, Lavallee, Gray-Donald, & Delisle (1995) reported that Cree children who were overweight consumed significantly fewer servings of milk and fruits and vegetables than normal weight Cree children. Hanley et al. (2000) found that fiber consumption in the previous 24 hours was associated with a reduced risk of overweight in 10-19 year old First Nations children. We found similar results; normal weight children consumed significantly more milk than obese children and they consumed significantly more fiber than overweight children. Consuming 2 or more servings of milk per day, being above the 75th percentile for fiber intake, and consuming 5 or more USDA food guide pyramid servings of fruits and vegetables per day was associated with reduced odds of overweight/obesity. It is important to note that fiber intake could not be categorized into having met or not met dietary reference intakes as no children met fiber intake recommendations (Institute of Medicine, 2005). Additionally, fruit and vegetable consumption was low among Cree children. Our study showed that only 39% of children consumed 5 or more USDA food guide pyramid servings of fruits and vegetables. The observation that 84% of children consumed fewer than three fruits (not including 100% fruit juice) and vegetables (not including french fries) daily is considerably higher than the Canadian Community Health Survey that found that 59% of Canadian children and adolescents consumed fewer than 5 fruits (including fruit juice) and vegetables (not including french fries) per day (Shield, 2005). In that survey, children and adolescents who ate fruits and vegetables five or more times per day, were less likely to be overweight and obese (Shields, 2005). Our results corroborate this finding, as consuming 5 or more servings of fruit and vegetables was associated with reduced odds of overweight/obesity.

The aforementioned dietary characteristics indicate that normal and overweight children may have a higher quality diet than obese children based on the observation of higher intakes of vitamin A and vitamin D. The higher vitamin D intakes of normal and overweight children are most likely a reflection of their greater consumption of milk given that vitamin D is a nutrient found in only a few foods such as fortified milk, organ meats and oily fish (Gibson, 2005). In our study, consuming 2 servings or more of milk on a daily basis was associated with reduced odds of overweight/obesity. Other studies have found similar association between milk intake and weight status (Bernard et al, 1995; Barba et al., 2005; Skinner et al., 2003; Carruth & Skinner, 2001). Because the rise in obesity has coincided with a decrease in milk intake, some researchers have hypothesized that the two may be etiologically related (Huang et al., 2004). Conjugated linoleic acid (CLA), a group of unsaturated fatty acid isomers found in milk, has been proposed to have a role in the relationship between milk consumption and weight status; however, evidence for this relationship remains conflicting in human studies (Riserus et al., 2004). Alternative theories involving the role of milk in weight maintenance and weight loss involve the displacement of sweetened drinks with milk and the metabolic affects of calcium (Huang & McCrory, 2005). We found no evidence of decreased sweetened beverage consumption in normal weight than obese children. Nevertheless, because there are many confounding factors that are associated with dietary intake, it is difficult to determine the role of dairy in moderating weight status (Huang & McCrory, 2005).

By looking at the top contributing foods to the diet, it is evident that foods of high nutrient density are not commonly consumed in this population. With the exception of milk and real fruit juice, the top ten foods contributing to calories and calories from fat were energy dense foods of low nutritional value. The top 10 foods contributing to energy and energy from fat in the diet were similar across weight status groupings. The top contributor to energy among all weight categories was sweetened beverages; accounting for nearly 9% of all calories consumed. Snack foods (potato chips, Doritos, corn chips etc.) were the highest contributor of calories from fat in the diets for normal weight and obese children and the second highest contributor to fat in the diets of overweight children. Similar observations have been made with children from other First Nations and American Indian communities (Trifonopoulos, Kuhnlein, & Receveur, 1998; Lytle et al., 2002; Stroehla, Malcoe, & Velie, 2005). Trifonoupoulos et al (1998) found that the top three contributors of energy to the diet in the Kahnawake Schools Diabetes

Prevention Project were white bread, french fries and 2% milk, while the top three contributors of fat were french fries, frankfurters and bologna, and ground beef. Stroehla et al. (2005) noted that top sources of most dietary components were low-nutrient-dense high fat foods and refined carbohydrates in rural white and Native American children; which is congruent with our findings. Considering the relatively high contribution of milk to calories from fat, in Cree children it is important to note that the majority of the milk consumed in both communities was 2% milk. In an effort to reduce fat intake, replacing 2% and homogenized milk with 1% or skim milk would decrease the calories in milk from fat.

3.5 STRENGTHS & LIMITATIONS

Few studies with First Nations children have used direct measures of physical activity. Although we objectively measured physical activity using pedometers, a limitation of the study was the use of 2 days of pedometer measures for monitoring physical activity levels; four to five days of monitoring in children is suggested (Tudor-Locke et al., 2004; Vincent & Pangrazi, 2002). Pilot testing identified decreased compliance for returning pedometers when more than two days of pedometer monitoring were conducted. The use of accelerometers rather than pedometers would have permitted us to assess the intensity of physical activity, potentially permitting a better understanding of the association of lifestyle factors with weight status. Furthermore, the 20-meter shuttle run test is a motivational test, and the motivation to complete the test may have varied across weight categories.

The use of three 24-dietary recalls has seldom been used, and thus there has been a lack of account for day to day variability in food intake (Stein, Shea, Basch, Contento,

& Zybert, 1991). One of the major strengths of our study was the use of three days of 24-hour dietary recalls. Multiple repeated administrations of 24-hour dietary recalls on non-consecutive days are required to estimate the habitual intake of children with acceptable precision (Stein et al., 1991). Nevertheless, the inherent biases of dietary reporting are an important limitation of our study.

3.6 CONCLUSION

Our study corroborates previous findings of high prevalence of overweight and obesity in Aboriginal children. We provided valuable information in terms of the foods being consumed, physical activity levels and fitness levels of the children in this population. Our findings that fiber, milk, and fruit and vegetable consumption were associated with decreased odds of overweight and obesity suggest possible targets for the development of culturally sensitive empirically derived interventions.

Table 3-1. The association of weight categories with dietary and non-dietary variables

Variable	Normal Weight	Overweight	Obese	P-value	Total
No. of children	62	54	62		178
% Girls	46.8	61.1	58.1	.253	55.1
	Non-dietary data				
Age	10.6 ± 1.0	10.7 ± 1.0	10.7 ± 1.0	.786	10.6 ± 1.0
Height (m)	1.46 ± 0.08^a	1.47 ± 0.08^a	1.52 ± 0.08^b	.000	1.49 ± 0.08
Weight (kg)	38.5 ± 5.8^a	49.0 ± 8.1^b	67.3 ± 12.8^c	.000	51.7 ± 15.4
Waist circumference (cm)	65.2 ± 5.8^a	76.5 ± 7.5^b	92.6 ± 9.4^c	.000	78.1 ± 13.8
Pedometer score (steps/day)	14662 ± 3995^a	15195 ± 5020^a	12892 ± 5197^b	.024	14207 ± 4830
Shuttle run time (min)	3.3 ± 1.2^a	2.5 ± 0.9^b	1.7 ± 0.8^c	.000	2.5 ± 1.2
	Energy and macronutrients				
Calories (kcal)	2392 ± 779^a	2065 ± 498^b	2235 ± 630^a	.029	2238 ± 661
Calories per kilogram (kcal/kg)	63.4 ± 22.1^a	43.4 ± 13.2^b	34.1 ± 10.5^c	.000	47.1 ± 20.4
% energy from fat	29.8 ± 4.1	29.0 ± 5.4	30.5 ± 5.3	.255	29.8 ± 4.9
% energy from saturated fat	10.6 ±1.9	10.6 ± 2.0	10.9 ± 2.0	.720	10.7 ± 2.0
	Micronutrients and fibre				
Vitamin A (RAE)	377.2 ± 266.4^a	362.4 ± 218.2^a	268.5 ± 185.4^b	.017	334.8 ± 230.2
Vitamin D (µg)	4.5 ± 3.4^a	4.0 ± 2.3^a	3.3 ± 2.3^b	.037	3.9 ± 2.8
Vitamin C (mg)	115.7 ± 87.8	102.2 ± 81.6	96.4 ± 57.9	.360	104.9 ± 76.7
Calcium (mg)	976.5 ± 505.5	839.2 ± 292.3	820.8 ± 338.6	.060	880.6 ± 397.7
Iron (mg)	14.7 ± 6.0	13.5 ± 4.2	13.7 ± 5.4	.422	14.0 ± 5.27
Zinc (mg)	8.3 ± 3.6	8.3 ± 3.6	7.7 ± 3.2	.592	8.1 ± 3.5
Fibre (g)	15.0 ± 6.0^a	11.9 ± 3.9^b	13.0 ± 4.7^a	.003	13.4 ± 5.1
	Foods consumed				
Sweetened drinks (ml)	524.1 ± 336.2	416.9 ± 297.6	500.8 ± 376.7	.214	483.5 ± 341.2
Milk (ml)	384.6 ± 302.5^a	332.8 ± 196.3^a	262.7 ± 196.7^b	.019	326.4 243.0
Fruits and vegetables (number)	1.7 ± 1.3	1.5 ± 1.2	1.3 ± 1.2	.205	1.5 ± 1.2
Fruits and vegetables	5.1 ± 2.2	4.4 ± 2.0	4.3 ± 2.0	.078	4.6 ± 2.1

(servings)					

Different superscript letters indicate differences among groups.

Table 3-2. Normal weight versus overweight/obesity and waist circumference above or below the 85th percentile of NHANES III

	Normal Weight (n=62)	Overweight or Obese (n=116)
Waist Circumference<85th percentile (n=85)	60	25
Waist Circumference>85th percentile (n=93)	2	91

Table 3-3. The correlation between pedometer scores and shuttle run times among weight categories

Weight Status	Correlation between Physical activity and Physical Fitness	p-value
Normal Weight	.411	.001*
Overweight	.275	.044*
Obese	.157	.222
Total	.310	.000*

* denotes significance ($p<0.05$) using the chi-squared test

Table 3-4. The 10 contributing foods to calories and calories from fat by weight status

	Combined Weight Categories		Normal Weight		Overweight		Obese	
	%Total Calories	%Calories from fat	%Total Calories	%Calories from fat	%Total Calories	%Calories from fat	%Total Calories	%Calories from fat
Sweetened Beverages[1]	8.8 (1)	------	8.6 (1)	------	8.9 (1)	------	8.6 (1)	------
Milk	7.4 (2)	8.2 (2)	8.3 (2)	9.1 (3)	8.0 (2)	9.0 (1)	5.9 (4)	6.6 (4)
Snack Foods[2]	6.3 (3)	11.6 (1)	6.8 (3)	12.8 (1)	4.7 (6)	8.9 (2)	7.4 (2)	13.1 (1)
White Bread	6.3 (3)	3.7 (10)	6.1 (4)	3.7 (9)	6.5 (3)	------	6.4 (3)	3.9 (8)
Poutine	5.1 (5)	7.9 (3)	5.9 (5)	9.2 (2)	4.3 (7)	6.9 (3)	5.1 (6)	7.5 (3)
Pizza	4.4 (6)	6.0 (5)	4.3 (7)	5.8 (6)	4.9 (4)	6.5 (4)	4.1 (8)	5.7 (5)
Real Fruit Juice	4.3 (7)	------	3.7 (9)	------	4.7 (5)	------	4.7 (7)	------
Chicken	4.2 (8)	6.6 (4)	-------	5.9 (5)	-------	5.5 (8)	5.5 (5)	8.5 (2)
Cereal	4.1 (9)	------	4.2 (8)	------	4.2 (8)	-------	4.0 (9)	------
Cookies	3.5 (10)	5.2 (8)	4.4 (6)	6.4 (4)	3.7 (9)	5.8 (6)	-------	3.3 (10)
Fruit	------	------	3.7 (10)	------	-------	-------	-------	------
Hot dog	------	5.3 (7)	--------	4.0 (8)	-------	6.4 (5)	3.3 (10)	5.6 (6)
Butter	------	5.3 (6)	--------	4.9 (7)	-------	5.8 (7)	-------	5.3 (7)
Beef	------	4.0 (9)	--------	------	-------	5.0 (9)	-------	3.7 (9)
Ice Cream	------	------	--------	3.4 (10)	-------	-------	-------	------
Traditional Foods[3]	------	------	--------	------	3.7 (10)	-------	-------	------
Baked Goods[4]	------	------	--------	------	-------	3.8 (10)	-------	------

[1] pop, tang, kool-aid, etc.
[2] potato chips, tortilla chips, corn chips, etc.
[3] bear, moose, goose, moose stew, rabbit, beaver
[4] cakes, banana bread, strudels, pie, etc.

Table 3-5. The unadjusted odds ratios for lifestyle factors and reduced odds of overweight/obesity

Variable	Odds Ratio (95% CI)
Met Fruit and Vegetable recommendations (5 or more USDA food guide pyramid servings)	.487 (.259, .916)
Consumed 2 or more servings of milk per day	.455 (.213, .971)
Above the 75th percentile for fiber intake	.445 (.223, .889)
Consumed fewer than 3 restaurant meals in the three days of dietary recalls	2.15 (.794, 5.78)
Met pedometer recommendations (12,000 for girls, 15,000 for boys)	.630 (.332, 1.20)
Consumed less than 30% of calories from fat	1.04 (.561, 1.93)
Consumed less than can (355ml) of sweetened beverages per day	1.28 (.641, 2.25)

Table 3-6. Consuming 5 or more USDA servings of fruits and vegetables per day in relation to weight status.

Variable	Normal Weight (n=62)	Overweight/Obese (n=116)
Did not meet fruit and vegetable recommendations (5 or more USDA food guide pyramid servings) (n=109)	31	78
Met fruit and vegetable recommendations (5 or more USDA food guide pyramid servings) (n=69)	31	38

Table 3-7. Consuming 2 or more servings of milk per day in relation to weight status.

Variable	Normal Weight (n=62)	Overweight/Obese (n=116)
Consumed fewer than 2 servings of milk (n=144)	45	99
Consumed 2 or more servings of milk (n=34)	17	17

Table 3-8. Fiber intake in relation to weight status.

Variable	Normal Weight (n=62)	Overweight/Obese (n=116)
Below the 75th percentile for fiber intake (n=134)	40	94
Above the 75th percentile for fiber intake (n=44)	22	22

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4. RESTAURANT INTAKE AND THE HOME FOOD ENVIRONMENT OF CREE CHILDREN

4.1 INTRODUCTION

Overweight and obesity in Canadian children is prevalent and increasing (Shields 2005; Tremblay & Willms, 2000). Both the community and home food environments mediate eating behavior through the access and availability of foods (Haire-Joshu & Nanney, 2002). The increase in childhood obesity is undoubtedly due in part to recent dramatic changes in these food environments. Children are consuming a greater number of their meals from sources outside the home (Morill & Chinn, 2004, Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004; Nielsen, Siega-Riz, & Popkin, 2002). Indeed, since the late 1970's, energy intake from restaurant meals/fast foods increased by 91% - 208% for all age groups (Nielsen et al., 2002); as many as 30.3% of American children eat fast food restaurant meals on a given day (Bowman et al., 2004). Meals served at restaurants and fast food establishments are generally energy dense foods with low nutritional value, and the portions served typically exceed USDA recommended portion sizes (Pereira et al., 2005). Because children and adolescents have not yet developed cognitive dietary restraint, they may be particularly vulnerable to obesity that results from overconsuming high energy density, fast foods (Prentice & Jebb, 2003). As convenience becomes a priority in many households, the home food environment has changed to include an increased number of away from home (i.e., take-out) and pre-prepared foods (Anderson & Butcher, 2006). The availability of foods in the home, such as fruits and vegetables, has consistently shown a strong correlation with actual intake (Neumark-Sztainer, Hannan, Story, Croll, & Perry, 2003; Hanson, Neumark-Sztainer, Eisenberg, Story, &Wall, 2005; Davis et al., 2000; Haire-Joshu & Nanney, 2002; Bere & Kelpp, 2004; Cullen et al., 2003). However, when take-out foods make a substantial contribution to the home diet, the association between availability of food at home and foods consumed at home may become less pronounced.

In Canada, as in the United States, First Nations (American Indian) children often have higher rates of overweight and obesity than do other children (Willows, 2005a; Shields, 2005; First Nations Centre, 2005; Story et al., 2003). In the United States, there has been an increase in the number of fast food restaurants and convenience food markets on or near some reservations (Broussard et al., 1995) and it is likely that a comparable situation exists for reserves in Canada. First Nations undergoing the nutrition transition have an increasing proportion of their diet from store-bought foods and a decreasing proportion from traditional foods obtained from hunting, trapping, fishing and gathering (Kuhnlein et al., 2003; Gittelsohn et al., 1998; Willows, 2005b; Simoneau & Receveur, 2000; Taylor, Keim, & Gilmore, 2005; Harris, Perkins, & Whalen-Brough, 1996). More than half of First Nations live off-reserve and in cities, limiting access to traditional foods (Siggner, 2003). Many reserves in Canada are in rural or remote regions of the country and have limited access to nutrient dense healthful foods, including traditional foods, due to lack of availability or high cost. As a result, diets are high in fat and sugar (Curran et al., 2005; Willows 2005b).

Despite the high rates of obesity that have accompanied the nutrition transition to market foods of low nutritional quality (Kuhnlein et al., 2003), there has been limited study of the association of the community and home food environment on the dietary intake and weight status of First Nations children. We did a school-based study of First

Nations children to examine the association between child reported household food availability and restaurant/take-out meal frequency with dietary intake and weight status in two subarctic Cree communities.

4.2 SUBJECTS & METHODS

The Emiyuu Ayayaachiit Awaash Project (The Active Kids Project) was a study of children's diets, activity levels, physical fitness and weight status that was conducted in two schools in two Cree communities in northern Quebec. One community was rural and the other remote; both had populations less than 3,500 people. Market foods sold in community grocery stores were often costly (Willows, Iserhoff, Napash, Leclerc, & Verrall, 2005). Each community had three restaurants that served fast foods such as poutine (french fries, brown sauce, cheese curds), french fries, hamburgers, fried battered chicken and pizza. Fried chicken and french fries were sold ready-to-serve in some grocery stores. Some residents set up fast food canteens and snack stands in their homes to make additional revenue. The schools did not have meal programs, although one offered children food from a snack cart, and children ate breakfast and lunch away from school.

All students who regularly attended grades 4-6 were eligible to participate. Prior to the commencement of the study, students were given information sheets and parental consent forms, researchers met with school and Cree Health Board staff to discuss the study, and radio announcements were broadcast in each community to inform community members about the study. The study was approved by the Human Ethics Research Board, Faculty of Agriculture, Forestry, and Home Economics, University of Alberta.

The Cree Board of Health and Social Services of James Bay and the school Principal in each community also approved the study.

a. Weight Status

To document children's weight status, body mass index (BMI) was calculated from children's measured heights and weights (Ng, Marshall, & Willows, 2006). Researchers were trained in the proper techniques to perform anthropometric measurements by an Exercise Scientist to ensure accuracy of measurement. Weight was measured to the nearest pound on a Health-O-Meter Professional Scale, Model HAP 300-01. Children were asked to remove any bulky clothing and their shoes to ensure the accuracy of the weight measurement. Height was taken with the children's shoes off. A set square was placed on the top of the child's head and children stood erect with weight equally distributed between both feet. Children were asked to take a deep inhalation and to hold their breath; at this point the height measurement was taken. Height was measured to the nearest tenth of a centimeter. BMI was calculated by dividing weight in kilograms by height in meters squared by (kg/m^2). International Obesity Task Force Cut-Offs were used to categorize children's BMI's as normal weight, overweight, or obese (Cole, Bellizzi, Felgal, & Dietz, 2000).

Waist circumference was measured to the nearest tenth of a centimeter with an inelastic measuring tape. Waist circumference was measured at the smallest circumference below the rib cage and above the umbilicus when the child was standing with their abdominal muscles relaxed. In the case where there was no visible natural waist the measurement was performed at the level of the umbilicus. The child was asked to take a deep inhalation followed by a deep exhalation; at this point the measurement was taken. Waist circumference measurements were compared to the Third National Health and Nutrition Examination Survey (NHANES) age and sex specific reference data. If children exceeded the 85th percentile of the reference data they were considered to have abdominal obesity.

b. Physical Activity and Fitness

Students wore pedometers on two days to assess physical activity levels (Ng et al., 2006). Students completed the Leger 20-meter shuttle run test (Leger, Mercier, Gadoury, & Lambert, 1984) during physical education class to assess physical fitness levels (Ng et al., 2006). To assess physical fitness levels, shuttle run times and the last shuttle run stage completed were recorded and compared to normative data from Quebec schoolchildren (Leger et al., 1984).

c. Dietary Intake

To measure dietary intake, trained researchers conducted three 24-hour dietary recalls with each child on non-consecutive days, including one weekend day. Most children spoke Cree as their mother tongue, with English as their second language. In the remote community where Cree was more predominant, a translator was present to aid children who had difficulties speaking or understanding English. Probes, food models, and pictures and packaging of locally sold products were used to obtain detailed information regarding food and drinks consumed, as well as quantities and methods of preparation. A multiple-pass dietary interview method was performed when conducting 24-hour recalls (Gibson, 2005; Arnold, 2006).

Dietary information from 24-hour recalls was entered into Food Processor SQL for Windows (Food Processor SQL, Esha Research, Salem, Oregon). The Canadian nutrient file was used to better reflect the nutrient composition of foods and beverages consumed by children. Sweetened drinks (powdered fruit drinks, sports drinks and other drinks with added sugars) were considered a single category and a separate category was formed for carbonated soda. Fruits and vegetables were reported as the absolute number of fruits and vegetables consumed (excluding french fries and fruit juices), and as number of USDA servings of fruits (including 100% fruit juice) and vegetables (including french fries) (USDA, 1992). Food processor did not report food servings according to Canada's food guide to healthy eating.

d. Restaurant and Take-out Food

Children were asked the source of their meal (restaurant/take-out or prepared in the home). Parents often purchased food from restaurants as take-out food to be consumed at home. The number of meals reported to be from restaurant or take-out in the three days of recall were categorized as none, 1 or 2, or 3 or more.

e. The home food environment

The home food environment was assessed using a food availability questionnaire that was adapted from the food availability portion of the University of Minnesota Project Eating Among Teens Survey (Neumark-Sztainer et al., 2003; Hanson et al., 2005). Children were asked questions regarding the availability of fruits and vegetables (in the home and on their plate at dinner), chocolate and candy, milk, soda pop, potato chips and real fruit juice in their home. For each question, children were asked to respond that the item was never, sometimes, usually or always available. Due to the small number of responses for some categories, for statistical analyses the 'usual' and 'always' categories were combined, as were the 'sometimes' and 'never' categories.

f. Statistical Analysis

Statistical analyses were performed using SPSS for Windows version 14.0. T-test and ANOVA (p-value <0.05) were used to assess group differences for continuous variables. The Bonferroni statistic was used to determine differences among groups. To test for group differences for continuous variables that were not normally distributed, the Mann-Whitney U test (two groups) or the Kruskal-Wallis test (three groups) were used. Continuous variables were reported as the mean (± 1SD). For variables that were not normally distributed, the median and interquartile range were reported. The Chi-Square test was used to test group differences involving categorical data.

4.3 RESULTS

Two hundred and twenty five students were eligible to participate; 208 received parental consent and 201 had dietary and anthropometric data (participation rate 89%). A smaller number of children with dietary information had completed the shuttle run test of fitness (n = 178) or had pedometer scores (n = 181).

Children had high rates of overweight (29.9%) and obesity (34.3%). More than three-quarters (77.6%) of children consumed at least one meal from restaurant or take-out during the three days of dietary recall and 18% of children consumed three or more restaurant or take-out meals (table 4-1). Children who ate fewer than three meals from restaurant/take-out as compared to children who consumed three or more meals from restaurant/take-out in the three days of recall consumed significantly more energy from protein, but fewer calories, fat and saturated fat calories, percent energy from fat, and calcium. They also consumed fewer USDA vegetable servings. Children who ate no restaurant/take-out meals in the three days of recall consumed the smallest quantity of sweetened drinks (not including soda) than children who consumed restaurant/take-out meals. Soda consumption increased with increasing frequency of restaurant/take-out meals. Restaurant/fast-food meal frequency was not significantly associated with BMI, weight status, fiber, vitamin's A, D, C, iron, zinc, milk, shuttle run time or pedometer scores.

The percentage of children reporting 'always' to household availability of foods was: potato chips (7%), fruits and vegetables (54%), chocolate and candy (6%), real fruit juices (52%), soda pop (15%), milk (81%), and vegetables on their dinner plate (28%). There were no statistical differences in the home food environment of normal weight children versus overweight/obese children based on household food availability categories (data not shown). The food environment was associated with dietary intake. Children who reported usually/always having soda, real fruit juice, or milk in their house to drink consumed significantly greater amounts of these beverages in comparison to children who reported never/sometimes having these beverages in their homes (Table 4-2). Children who reported usually/always having milk available in their homes had significantly higher intakes of calcium; 202mg more per day (897mg vs 696mg, p =0.012). Paradoxically, although there was no significant difference in the number of vegetables consumed between children who reported usually/always and never/sometimes having vegetables on their plates at dinner, children who reported never/sometimes having vegetables on their plates at dinner consumed a significantly greater number of USDA servings of vegetables. These children also consumed significantly more meals at the restaurant or from take-out than did children reporting usually/always having vegetables on their plate at dinner (p=.020).

4.4 DISCUSSION

Our findings in elementary school Cree children living in a remote or rural community corroborate previous research that children who eat fast food or restaurant meals have poor diet quality. Despite the remoteness of communities, 77% of the Cree children consumed at least one meal from restaurant/take-out during the three days of food recall, which is comparable to findings that one-third of children eat fast food restaurant meals on a given day (Bowman et al., 2004). The foods consumed at restaurant and fast food establishments are generally energy dense and contain high amounts of fat and sugar (Prentice & Jebb, 2003). The energy content of restaurant meals has been found to be 55% higher, on average, than for home-based meals (Zoumas-Morse, Rock, Sobo, & Neuhouser, 2001). When children and adolescents eat at restaurants they consume significantly more energy from fat and energy from saturated fat than when eating meals consumed at home or at school (Zoumas-Morse et al. 2001). In addition, French, Story, Neumark-Sztainer, Fulkerson, & Hannan (2001) reported a dose response pattern where energy and percent energy from fat increased according to the frequency of fast food restaurant use in adolescents. Moreover, French et al. (2001) found that adolescents who consumed the most fast food restaurant meals had a higher intake of soda. Even when fast foods are not commonly eaten, they can substantially contribute to energy and fat intake. For example, a study that reported the frequency of fast food meals in Navajo American Indians aged 12-91 years of age found that three percent of foods mentioned in the single 24-hour recall were fast foods; however these foods contributed to 8% of total energy, 11% of total energy from fat, and 13% of total energy from saturated fat (Ballew et al., 1997).

It was not surprising that Cree children who consumed the most meals from restaurant or take-out had several macronutrient, micronutrient and dietary differences from children consuming fewer or no meals from restaurant/take-out. In particular, children who consumed the most restaurant/take-out meals consumed the most calories, calories from fat and saturated fat, and quantities of soda, in addition to a lower proportion of energy from protein. Bowman et al. (2004) reported that children who consumed meals from fast food restaurants consumed, on average, 187 more calories per day than children who did not consume these meals. Our observations suggest an even greater difference in the caloric intake of children consuming restaurant/take-out meals; children consuming three or more meals in three days of recall had an average daily intake of 479 more calories per day than children consuming no restaurant/take-out meals.

In children, a relationship between weight status and frequency of restaurant and take-out meal consumption is not apparent despite the higher caloric intake associated with fast foods (Anderson & Butcher, 2006). Likewise, in Cree children, weight status was not associated with frequency of restaurant/take-out meals. Ebbeling et al. (2004) conducted a study to address the relationship between weight status and fast food intake. Their findings suggest that adolescents over consume fast food regardless of their body weight. However, the lean adolescents compensate for the energy in fast food by adjusting their energy intake throughout the day whereas the overweight adolescents fail to do so. Therefore, children who frequently consume energy dense meals served at restaurant and fast food establishments might not increase their body weight if they maintain energy balance. However, inactive children who frequently consume energy dense meals may have difficulty maintaining energy balance. In Cree children, we were unable to accurately assess the relationship between restaurant/take-out frequency categories and physical activity measures due to confounding variables such as sex, pooled weight status, pubertal status and fewer children with physical activity data. It is possible that the cross-sectional nature of the study and the younger age of the children in the highest restaurant frequency category contributed to the lack of relationship between BMI and restaurant food intake behavior in our study.

Adolescents consuming fast food restaurant meals have lower micronutrient intakes, particularly for calcium, vitamin A, vitamin C and carotene (French et al., 2001). Interestingly, in our study children who consumed three or more restaurant/take-out meals had a higher intake of calcium than children who consumed fewer restaurant/take-out meals despite no differences in milk intake among restaurant frequency categories. The reason for this difference is unknown and may be the result of an increased consumption of cheese from poutine (fries, brown sauce and cheese curds), which was a commonly consumed restaurant/take-out item. Surprisingly, we found that children who consumed the most restaurant/take-out meals had the highest number of USDA vegetable servings, although the number of vegetables consumed did not differ among restaurant frequency categories. This paradox suggests that the increased vegetable servings can be attributed to the consumption of french fries because fries were included as a USDA vegetable servings but were not included in the calculation of number of vegetables consumed. Although fries are considered vegetables in the USDA food guide pyramid, it is important to recognize that they are not a healthy choice. Including french fries as a vegetable serving may inflate the number of children who appear to be meeting healthy vegetable recommendations, particularly in populations where many children consume large quantities of fries.

The home food environment was associated with differences in the dietary intake of soda, real fruit juice and milk. Children who reported usually/always having soda, real fruit juice and milk in the home consumed a significantly higher quantity of these beverages than children reporting never/sometimes having soda and milk in the home. In addition, children reporting always having access to milk had a significantly higher calcium intake (202 mg) per day than children reporting never/sometimes having milk in the house to drink.

The availability of fruits and vegetables has consistently been found to be a very strong predictor of actual intake in many studies (Davis et al., 2000; Neumark-Sztainer et al., 2003; Haire-Joshu & Nanney, 2002; Bere & Klepp, 2004; Cullen et al., 2003). Neumark-Sztainer et al. (2003) found that out of 13 proposed factors considered to affect the intake of fruits and vegetables in adolescents, taste and availability were the only significant variables. Hanson et al. (2004) found that the median intakes of fruits and vegetables consumed by girls who reported always having fruits and vegetables available was 1.3 servings more than if girls reported never/sometimes having fruits and vegetables available in the home. No differences were found in the intakes of boys.

We found no significant differences among household fruit and vegetable availability categories and reported number of fruits and vegetables consumed, which contradicts other studies stating that availability is a determinant of intake. Interestingly, children who reported never/sometimes having vegetables on their plates at dinner had a significantly higher intake of vegetable servings than children reporting usually/always having vegetables on their plates at dinner; although the differences was less than a half a serving size. Similar to the differences in vegetable servings found among the restaurant frequency categories, the difference may be attributable to a higher consumption of french fries. This suggestion is supported by the finding that children who reported never/sometimes having vegetables on their plates at dinner consumed significantly more meals from restaurant/take-out than children who usually/always had vegetables on their plates at dinner.

The mean number of servings of fruit and vegetable was below the recommended five servings a day (Health Canada, 2006). American Indians have been found to have a high risk for inadequate intakes of fruits and vegetables (Neumark-Sztainer, Story, Resnick, & Blum, 1996). Trifonopoulos, Kuhnlein, & Receveur (1998) reported low intakes of fruits and vegetables in Canadian Mohawk children. The cost of fruits and vegetables on reservations and reserves are often inflated in comparison to urban areas and the quality of the produce in the community grocery stores is often sub-standard (Curran et al., 2005; Willows, 2005b). In Canada, fruits and vegetables are more expensive in rural areas due to transportation costs (Willows, 2005b). Expense may in part explain the low intake of fruits and vegetables and availability of fruits and vegetables in participating children's households.

We found previously that the top contributors of energy and energy from fat in the diet of Cree children were soda and snack foods, respectively, yet a large proportion of the children in the current study indicated never/sometimes having potato chips, candy and soda available in their homes. This suggests that children bought these energy dense foods outside the home, perhaps on their way to and from school, or misreported the availability of these less desirable foods at home. Since children, in general, are consuming a large number of meals from restaurant/take-out it becomes increasingly interesting to examine the home food environment and its relationship with actual intake. It is plausible to suggest that because there are fewer meals being consumed in the home, measuring the home food environment as an indirect proxy measure of actual intake loses its relevance. Although we found that for beverages, dietary intake reflected household food availability despite many children eating restaurant meals, where children eat a preponderance of meals away from the home, measuring the community nutrition environment as a whole may be a more relevant means of measuring intake behavior than measuring the home food environment (Glanz, Sallis, Saelens, & Frank, 2005).

Our findings indicate that even young children are able to report accurately on their home food environment. Despite dietary intake being modified by the home food environment, we found no associations between children's weight status and the home food environment. Gable & Lutz (2000) also found for children 6-10 years of age that the home food environment between obese and non-obese children did not differ.

4.5 STRENGTHS & LIMITATIONS

One of the strengths of this study was the use of three 24-hour dietary recalls on non-consecutive days including one weekend day. Many studies complete only one recall with each participant, thereby not accounting for day to day variability in the diet (Gibson, 2005). Nevertheless, it is important to acknowledge the inherent biases of dietary data as they are prone to under and over reporting leading to inaccuracies in dietary information (Livingstone, Robson, & Wallace, 2004). Another strength of this study was asking the children the sources of their meals. This made it possible for us to make associations between restaurant/take-out intake and diet quality. Many studies neglect to examine this relationship.

4.6 CONCLUSION

Restaurant/take-out meal frequency and the home food environment do not appear to be associated with the weight status of Cree schoolchildren regardless of the finding that children who consumed the most restaurant/take-out meals consumed significantly more calories. However, it is possible that prospective studies that follow the long term consumption of restaurant/take-out meals in Cree children would identify a positive relationship between weight status and restaurant/take-out food intake. Children should limit their restaurant/take-out meals and parents should increase the availability of nutrient dense foods in the homes in an effort to improve dietary intake among Cree children.

Table 4-1. The association of frequency of restaurant/take-out intake meals in the three days of recall with dietary and non-dietary variables

Variable	O meals	1 or 2 meals	3 or more meals	P-value	Total
No. of children	45	119	37	NA	201
% Girls	55.6	62.2	37.8	.033	56.2
	Non-dietary data				
Age	10.9 ± 0.9^a	10.7 ± 1.0^a	10.3 ± 0.9^b	.016	10.7 ± 1.0
BMI (kg/m^2)	23.8 ± 4.7	22.9 ± 5.2	22.6 ± 5.1	.483	23.0 ± 5.1
Normal weight (%)	24	39	38	.504	35.8
Waist Circumference (cm)	81.2 ± 13.1	78.4 ± 14.8	76.0 ± 12.5	.247	78.6 ± 14.1
Abdominal obesity (%)	67	48	46	.074	52
	Macronutrients				
Calories (kcal)	2109 ± 564^a	2207 ± 671^a	2588 ± 792^b	.003	2255 ± 689
Energy from fat (kcal)	617 ± 235^a	663 ± 234^a	824 ± 266^b	.000	683 ± 249
% energy from fat	28.8 ± 6.0^a	29.9 ± 4.3^a	31.9 ± 4.8^b	.015	30.0 ± 4.9
Energy from saturated fat (kcal)	226 ± 83^a	238 ± 94^a	293 ± 89^b	.002	245.3 ± 93.5
% energy from saturated fat	10.5 ± 2.0	10.6 ± 1.9	11.4 ± 1.9	.071	10.7 ± 1.9
% energy from carbohydrate	57.0 ± 7.3	57.4 ± 5.5	56.0 ± 5.8	.472	57.0 ± 6.0
% energy from Protein	15.2 ± 3.4^a	14.1 ± 3.0^a	13.6 ± 2.7^b	.044	14.3 ± 3.1
Fiber (g)	13.1 ± 4.6	13.2 ± 5.3	14.6 ± 5.9	.346	13.4 ± 5.3
	Micronutrients				
Vitamin A (RAE)	374.4 ± 224.9	325.2 ± 229.2	309.0 ± 222.5	.360	333.2 ± 227.1
Vitamin D (μg)	4.1 ± 2.7	3.7 ± 2.5	4.3 ± 3.2	.384	3.9 ± 2.7
Vitamin C (mg)	110.9 ± 84.1	107.5 ± 77.0	96.5 ± 63.0	.669	106.2 ± 8.0
Calcium (mg)	844.8 ± 366.1^a	828.9 ± 388.0^a	1033.1 ± 390.3^b	.018	870.0 ± 389.5
Iron (mg)	14.6 ± 4.9	13.4 ± 5.1	15.1 ± 6.8	.166	14.0 ± 5.4
Zinc (mg)	8.9 ± 3.4	7.6 ± 3.3	8.2 ± 3.4	.067	8.0 ± 3.4

	Foods consumed				
Sweetened drinks[1] (ml)	177.4 (54.6-456.5)	319.3 (134.8-553.0)	276.7 (176.7-456.8)	.043	360.2 (118.3-492.1)
Soda (ml)[1]	60.0 (0.0-249.2)	120.0 (0.0-285.0)	333.3 (134.2-500.8)	.000	217.8 (0.0-334.3)
Milk (ml)	330.9 ± 232.8	306.5 ± 236.9	352.69 ± 245.1	.555	320.4 ± 237.0
Fruits (number)[1]	0.7 (0.0-1.5)	0.3 (0.0-1.0)	0.3 (0.0-1.0)	.634	0.8 (0.0-1.0)
Fruits (servings)[1]	2.6 (1.3-4.2)	2.1 (1.0-3.5)	1.9 (1.3-3.3)	.405	2.1 (1.2-3.5)
Vegetables (number)[1]	0.7 (0.3-1.3)	0.7 (0.0-1.0)	0.3 (0.0-0.7)	.253	0.7 (0-1.0)
Vegetables (servings)	1.5 ± 0.9^a	2.1 ± 1.3^a	2.9 ± 1.3^b	.000	2.1 ± 1.3

Different superscript letters indicate differences among groups.

[1] Kruskal-Willis Test was used due to abnormally distributed data

Expressed as means and standard deviations for normally distributed data and medians and interquartile range for data that were not normally distributed

Table 4-2. The child reported household availability of food in relation to actual intake

	Fruit & Vegetables in the home		
	Usually/Always available	Sometimes/Never available	p-value
Number of fruit & vegetables	1.3 (0.7-2.3)	1.0 (0.7-1.9)	.341
Servings of fruit and vegetables	4.8 ± 2.1	4.3 ± 2.2	.178
	Vegetables on plate at dinner		
	Usually/Always available	Sometimes/Never available	
Number of vegetables	0.7 (0.3-1.2)	0.3 (0.0-1.0)	.075
Servings of vegetables	1.9 ± 1.1	2.3 ± 1.4	.014*
	Real Fruit Juice in the Home		
	Usually/Always	Sometimes/Never	
Real Fruit Juice (ml)	236.5 (83.3-383.5)	150.1 (0.0-327.0)	.024**
	Pop in the home		
	Usually/Always available	Sometimes/Never available	
Soda (ml)	198.3 (60.0-434.3)	118.3 (0.0-296.0)	.049**
	Milk in the house to drink		
	Usually/Always available	Sometimes/Never available	
Milk (ml)	335.3 ± 244.6	224.8 ± 151.7	.024*

*Indicates significant differences using t-test, $p<0.05$

**Indicates significant difference using Mann-Whitney U test, $p<0.05$

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5. MICRONUTRIENT INTAKE AND FOOD SOURCES IN CREE SCHOOLCHILREN

5.1 INTRODUCTION

When evaluating the diet quality of a specific population or group it is important to examine the micronutrient composition of the diet. Recently, Canada and the United States collaborated with one another to establish nutrient reference levels to optimize health (Gibson, 2005). The dietary reference intake (DRI) guidelines were established to reduce the risk of chronic and degenerative disease, establish an upper level of intake designed to avoid risk of adverse health outcomes, and to include components of food not conventionally considered to be essential nutrients but which may have a possible health benefit (Gibson, 2005).

To estimate risk of inadequate or excess intake, the DRIs consist of four components: estimated average requirement (EAR), adequate intake (AI), recommended daily allowance (RDA), and tolerable upper intake (UI) level (Fitzgerald, 2002). EARs have yet to be established for vitamin D and calcium (Barr, Murphy, & Poos, 2002); AIs are therefore used as reference values.

Little is known about micronutrient intake and deficiencies in First Nations children. The objectives of this paper were to report micronutrient intake in comparison to DRIs in Cree children 9-12 years old, and to report the top food sources for important micronutrients.

5.2 SUBJECTS & METHODS

The Emiyuu Ayayaachiit Awaash Project (The Active Kids Project) was a study of children's diets, activity levels, physical fitness and weight status that was conducted in two schools in two First Nations communities in northern Quebec. All students who regularly attended grades 4-6 were eligible to participate. Prior to the commencement of the study, students were given information sheets and parental consent forms, researchers met with school and Cree Health Board staff to discuss the study, and radio announcements were broadcast in each community to inform community members about the study. The study was approved by the Human Ethics Research Board, Faculty of Agriculture, Forestry, and Home Economics, University of Alberta. The Cree Board of Health and Social Services of James Bay and the school Principal in each community approved the study.

Trained researchers conducted three 24-hour dietary recalls with each child on non-consecutive days, including one weekend day. Probes and food models were used to obtain detailed information regarding food and drinks consumed, as well as quantities and methods of preparation. A multiple-pass dietary interview method was performed when conducting 24-hour recalls (Gibson, 2005; Arnold, 2006). Children spoke Cree as their mother tongue, with English as their second language. In the remote community where Cree was more predominant, a Cree translator was present to aid children who had difficulties speaking or understanding English. Dietary information from 24-hour recalls was entered into Food Processor SQL for Windows (Food Processor SQL, Esha Research, Salem, Oregon). The Canadian nutrient file was used to better reflect the nutrient composition of foods and beverages consumed by children. The top five foods contributing to select micronutrients were derived. To calculate the percentage that foods contributed to vitamin A, D, C, calcium, iron, zinc and folate the micronutrient intakes associated with each food or food category were summed and divided by the total intake of the specific micronutrient. The average micronutrient intakes throughout the three days of dietary recall were used to compute the top food sources of micronutrients. PC-SIDE (Iowa State University, version 1.0) software was used to adjust micronutrient intakes and report risk of inadequacy based on the EAR cut-point method (Institute of Medicine, 2000a), report percent below AIs and to report adjusted means and standard deviations. Micronutrient intakes for each of the three days of dietary recalls were used to assess the risk of micronutrient inadequacy. Adjusted means were used to account for the day to day variability in micronutrient intakes. Unadjusted medians and ranges were calculated for the aforementioned micronutrients and t-tests were used to assess mean micronutrient differences between sexes ($p<0.05$ was considered significant).

5.3 RESULTS

Of the 225 children invited to participate in the study, 208 had parental consent and 201 reported dietary intake, providing a participation rate of 89%.

Adjusted means and standard deviations and unadjusted medians and ranges of micronutrient intakes for select nutrients are reported in table 5-1. The unadjusted means, standard deviations, medians and ranges are reported for vitamin D. Adjusted means and the risk of vitamin D inadequacy could not be assessed for vitamin D because an accurate estimation of vitamin D intakes for each of the three days of dietary recall could not be performed by food processor. This is likely a reflection of the small number of foods that contain vitamin D, resulting in a high day to day variability in vitamin D intake. Girls consumed significantly less iron than boys did, but no other micronutrient differences existed between the sexes. The percentage of children below estimated average requirements (EAR) and adequate intake (AI) levels are reported. Both boys and girls had a high risk of vitamin A, zinc and folate inadequacy. Most children (89.8%) were below the AI for calcium. Children had a low risk of vitamin C inadequacy and were above the EAR for iron intake.

Table 5-2 identifies the top five food sources of micronutrients. Milk was a major contributor to vitamin's A and D, zinc and calcium, as well as making contributions to folate. On average, children consumed 320 ml of milk, which was the equivalent to 1.3 servings. Milk recommendations for children aged 4 to 9 are 2-3 servings of milk per day and children and adolescents aged 10 to 16 are recommended to consume 3 to 4 servings per day (Health Canada, 2006). Less than one-fifth (19.1%) of children consumed at least 2 servings of milk daily and of these children, only 5.6% consumed 3 or more servings of milk daily. Eggs contributed to both vitamin A and D intake, and traditional food contributed to both iron and zinc intake. The top two contributors to vitamin C were real fruit juices and fruit drinks, of which children drank daily, on average, 241 ml (median 202 ml) and 360 ml (median 276 ml), respectively.

5.4 DISCUSSION

Previous studies have reported low intakes of vitamin A, calcium and folate among Indigenous adults (Simoneau & Receveur, 2000; Kuhnlein, Receveur, Soueida, & Egeland, 1996; Arbour et al., 2002) and children (Berti, Hamilton, Receveur, & Kuhnlein, 1999) in northern Canada. Our findings suggest a high risk of vitamin A inadequacy in First Nations children; over 70 percent of children were below the EAR for vitamin A. Moreover, almost 90 percent of children were below the AI for calcium; however risk for inadequacy can not be assessed because there is no EAR available for calcium. Girls had a higher risk of vitamin A, zinc and folate inadequacy and were more likely to have calcium intakes below the AI than boys.

Milk was a very important source of many nutrients. Our study suggests that children regularly consume milk, however many children are not consuming enough based on servings. In our sample population, milk provided approximately half of the intake of both vitamin A and calcium and nearly 90% of the intake of vitamin D. An inadequate intake of vitamin A can lead to decreased immune function, and inadequate intakes of calcium and vitamin D can lead to osteopenia and bone deformities, respectively (Gibson, 2005). Therefore, by increasing the number of servings of milk that children consume each day, an increase in vitamin A, vitamin D and calcium would be anticipated. Although the contribution was modest, milk also contributed to folate intake.

Vitamin D levels have been found to be low in Canadian Aboriginals living in Northern communities due to decreased exposure to sunlight in addition to a low dietary intake of vitamin D (Canadian Pediatric Society, 2002). There is a marked seasonal variation of sunlight exposure in extreme northern communities; sunlight induced vitamin D production in the skin may be absent for four to six months of the year in some northern communities (Canadian Pediatric Society, 2002). The Canadian Pediatric Society (2002) suggests that Aboriginal children who do not consume vitamin D fortified milk should consider vitamin D supplementation.

Most children (95%) exceeded the EAR for vitamin C intake, which is a common finding in North America (Institute of Medicine, 2000b). The reason for the high intake of vitamin C was the high intake of real fruit juice or fortified fruit drinks. Potato chips were also among the top five food sources of vitamin C in the diet. Similarly, Subar, Krebs-Smith, Cook, & Kahle (1998) reported potato chips to be one of the top ten food sources of vitamin C in a sample of US children aged 2-19 years. Ingesting the levels of vitamin C reported in the study population does not have negative health implications given that the average intake was below the tolerable upper intake level of 1200 mg/day (Institute of Medicine, 2000a). More problematic are that children's predominant sources of vitamin C contain a very large amount of sugar and calories, which may negatively affect dietary quality (Bachman, Baranowski, & Nicklas, 2006). Sources of vitamin C such as fruits and vegetables would be lower in calories and would not have added sugars.

Nearly two thirds (64.5%) of children had folate intakes below the EAR. Insufficient intakes of folate may result in fatigue, anorexia and ulcers (Gibson, 2005). The top three food sources of folate were bread and cereal, due to legislated fortification, and orange juice. As with vitamin C, potato chips were among the top five food sources of folate. Legumes and many dark green leafy vegetables contain considerable amounts of folate without the added fat and calories of potato chips; their consumption should therefore be encouraged.

Less than one percent of children were below the EAR for iron intake. However, because the requirement distribution for iron is skewed rather than symmetrical, risk of inadequacy can not be reported using the EAR cut-point method (Barr et al., 2002). The risk of zinc inadequacy was 42.8% of First Nations children. Low intakes of zinc have been associated with poor appetite, mental lethargy and skin changes (Gibson, 2005). A very positive finding in this study was the substantial contribution of traditional foods to both iron and zinc intake. Although only 3.0% of all calories consumed in the diet came from traditional foods, they contributed to 16.7% of the total intake of zinc and 16.8% of the total intake of iron. Berti et al. (1999) found low prevalence of inadequate intakes of iron, zinc, and protein in Baffin Inuit children and adolescents. Over 50% of iron and zinc in the diet was provided by traditional foods; traditional foods comprised 16% of total energy. Nakano, Fediuk, Kassi, Egeland, & Kuhnlein (2005) found that children who consumed traditional foods had significantly more protein, iron, zinc, copper, magnesium, phosphorus, potassium, vitamin E, riboflavin and vitamin B6 than those who did not consume traditional foods despite traditional foods contributing to only 5% of total energy. When traditional Arctic food is consumed, even in small quantities, nutrition for most micronutrients is improved (Kuhnlein et al., 2004). Traditional foods should be incorporated in the diet as a healthy means of improving or sustaining nutrient intake.

5.5 CONCLUSION

There was a low prevalence of vitamin C inadequacy and children were above the EAR for iron; however, the prevalence of vitamin A, zinc and folate inadequacy was more pronounced. Most children were below the AI for calcium. Our findings suggest that children had low quality diets and were not meeting micronutrient recommendations. Milk was a substantial source of several nutrients and traditional foods contributed to zinc and iron in the diet. Although intake of traditional foods may be low, the contributions to diet quality were substantial. Milk and traditional foods are important contributors to several micronutrients and their consumption should be promoted in an effort to improve diet quality. Moreover, Cree children should increase the consumption of high nutrient dense foods in lieu of the energy dense foods that are currently contributing to various micronutrients in the diet.

Table 5-1. Micronutrient intake and the risk of inadequacy

Micronutrient	Boys	Girls	Sexes Combined	P-value	EAR or AI
Vitamin A (RAE)					EAR 9-13y:
Mean ± SD	384.6 ± 200.0	322.9 ± 182.5	NA		♂ 445 µg/d
Median	293.1	254.6		.279	♀ 420 µg/d
Range	37.6-1298.3	6.8-1035.7			
% below EAR	69.0%	75.2%			
Iron (mg)					EAR 9-13y:
Mean ± SD	15.0 ± 4.5	11.3 ± 2.5	NA		♂ 5.9 mg/d
Median	14.8	12.1		.002*	♀ 5.7 mg/d
Range	5.39-37.0	3.3-34.7			
% below EAR	0.25%	0.18%			
Zinc (mg)					EAR 9-13y:
Mean ± SD	8.2 ± 2.6	7.1 ± 1.6	7.6 ± 2.1		7 mg/d
Median	7.7	7.0	7.3	.246	
Range	3.1-18.7	2.7-23.2	2.7-23.2		
% below EAR	35.9%	50.4%	42.8%		
Vitamin C (mg)					EAR 9-13y:
Mean ± SD	125.5 ± 60.6	96.8 ± 45.7	109.7 ± 54.9		39 mg/d
Median	98.7	89.5	94.6	.312	
Range	9.4-567.9	9.0-340.6	9.0-567.9		
% below EAR	2.6%	7.2%	4.9%		
Folate (µg)					EAR 9-13y:
Mean ± SD	258.5 ± 87.3	213.3± 75.8	233.7 ± 84.7		250 µg/d
Median	226.0	205.4	217.0	.231	
Range	66.2-710.1	55.8-764.5	55.8-764.5		
% below EAR	51.6%	74.1%	64.5%		
Calcium (mg)					AI 9-13y:
Mean ± SD	970.6 ± 389.0	817.4 ± 257.4	884.4 ± 316.4		1300 mg/d
Median	782.5	772.0	774.9	.166	
Range	305.8-2505.5	181.4-1867.5	181.4-2505.5		
% below AI	82.2%	95.6%	89.8%		

Vitamin D					AI
(µg)					4-13y:
Mean ± SD**	4.1 ± 3.0	3.7 ± 2.4	3.9 ± 2.7	.200	5 µg/d
Median	3.6	3.2	3.5		
Range	0.36-19.6	0.0-10.1	0.0-19.6		
% below AI	NA	NA	NA		

*Indicates significant difference between boys and girls unadjusted mean intakes of specified micronutrients, $p < 0.05$

**Indicates an unadjusted mean and standard deviation

EAR: Dietary reference intakes represented as estimated average requirements for groups (EAR)

AI: Adequate Intake

1 RAE = 1 µg of retinol

% below AI or EAR: The adjusted percentage of children with average nutrient intakes below the EAR or AI.

♀-the requirements for girls in the specified age group

♂-the requirements for boys in the specified age group

Table 5-2. Top five dietary contributors to vitamin's A, D, C and iron, zinc, calcium and folate

Micronutrient	Food Item	% of total micronutrient intake
Vitamin A (RAE)	Milk	49.5
	Carrots	11.5
	Eggs	9.4
	Spaghetti Sauce with beef	7.3
	Ice Cream	5.8
Vitamin D (µg)	Milk	89.3
	Eggs	3.5
	Ice cream	2.2
	Butter	1.8
	Cereal	1.5
Vitamin C (mg)	Real Fruit Juice	32.9
	Fruit drinks*	25.6
	Oranges	11.7
	Potato Chips	6.9
	Spaghetti Sauce with beef	2.4
Iron (mg)	Cereal	20.8
	Traditional food**	16.7
	White Bread	11.3
	Macaroni & Cheese	3.6
	Beef	3.2
Zinc (mg)	Traditional food**	16.8
	Milk	15.8
	Beef	9.6
	Cereal	8.6
	Chicken	5.4
Calcium (mg)	Milk	43.4
	Cheese	11.9
	Pizza	5.0
	Yogurt	3.5
	Ice Cream	2.7
Folate (µg)	Bread	17.0
	Cereal	10.1
	Orange Juice	10.1
	Milk	6.3
	Potato Chips	6.1

*fruit drinks: punches, kool-aid, pop, tang, etc.

**traditional foods: bear, moose, goose, moose stew, rabbit, beaver.

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6. SUMMARY AND CONCLUSIONS

Our results suggest extreme rates of overweight and obesity in children in Cree communities in Northern Quebec. Almost two thirds of children were overweight (29.9%) or obese (34.3%). In addition, abdominal obesity was identified in approximately half (52%) of children. Of the children who were classified as overweight or obese, 78% had abdominal obesity; central adiposity in children has been associated with metabolic abnormalities and the metabolic syndrome (Rodriguez, 2004; Esmaillzadeh, Mirmiran, & Azizi, 2006; Maffeis, Pietrobelli, Provera, & Tato, 2001a; Maffeis, Grezzani, Pietrobelli, Provera, & Tato, 2001b; Freedman, Serdula, Srinivasan, & Berenson, 1999).

The mean values for caloric and macronutrient intake suggests that children had acceptable dietary intakes. On average, children consumed 2238 ± 661kcal per day and 29.8% ± 4.9% of calories from fat per day. However, mean intakes may be misleading as almost half (46.1%) of children exceeded dietary fat recommendations of 30% or fewer calories from fat. Normal weight children had a significantly higher caloric intake than overweight children, and normal weight children had a significantly higher intake of calories per kilogram body weight than overweight and obese children. Patrick et al. (2004) reported similar results where normal weight children consumed more calories than at risk of overweight and overweight children. In that study, normal weight children engaged in significantly more vigorous physical activity than at risk for overweight and overweight children. Although we objectively measured physical activity levels in our study with pedometers, pedometers are unable to account for varying intensity in activity, leaving us incapable of determining whether normal weight children in our study were engaging in more vigorous physical activity leading to greater energy expenditure.

It is important to note the possibility that overweight and obese children underreported dietary intake. Previous research has not validated the use of 24-hour dietary recalls with Aboriginal children. However, between the ages of seven and 12, the novelty and the added curiosity of assisting in the reporting of food intakes may help sustain enthusiasm and thereby compliance in dietary monitoring (Livingstone & Robson, 2000); biases in dietary reporting were not likely the reason for the reported differences in caloric intake among weight categories.

Normal weight children consumed significantly more fiber than overweight children and significantly more milk than obese children. Furthermore, consuming 2 or more servings of milk per day, consuming 5 or more USDA food guide pyramid servings per day of fruits and vegetables, and being at or above the 75th percentile for fiber intake was associated with lower odds of overweight/obesity. These findings suggest that plausible intervention strategies should target increasing consumption of milk, fruits and vegetables and fiber in Cree children.

Fruit and vegetable consumption was low in Cree children. Sixty one percent of children consumed fewer than 5 USDA food guide pyramid servings of fruits and vegetables per day. Moreover, 83.7% of children consumed fewer than 3 total fruits and vegetables (not including french fries or fruit juice), on average, per day. The Canadian Community Health Survey reported that 59% of Canadian children and adolescents consumed fewer than 5 fruits (including fruit juice) and vegetables (excluding french fries) per day (Shields, 2005). In that survey, children who consumed more fruits and vegetables were less likely to be overweight or obese than children who consumed fewer fruits and vegetables (Shields, 2005). The findings of low fruit and vegetable intake and the negative association between fruit and vegetable intake and BMI suggests that public health messages should emphasize their consumption.

Although it appears that Cree children were consuming an acceptable number of calories and calories from fat in the diet based on mean intakes, results suggest that their dietary quality was relatively poor. Over three quarters (77.7%) of children reported consuming one or more meals from restaurant/take-out during the three days of 24-hour dietary recalls. Moreover, 18% of children consumed three or more meals from restaurant/take-out during the three days of 24-hour dietary recalls. Our study found that a greater frequency of restaurant/take-out meals was associated with pronounced dietary modification. Children who consumed three or more restaurant/take-out meals, in comparison to those who consumed fewer restaurant/take-out meals, consumed significantly more calories, fat calories, percent energy from fat, saturated fat calories, soda pop and sweetened beverages. In short, dietary quality decreased as the frequency of restaurant/take-out meals increased. Interestingly, weight status was not related to restaurant/take-out meal frequency; this lack of association between weight status and restaurant/take-out meal frequency has been previously reported in children and adolescents (French, Story, Neumark-Sztainer, Fulkerson, & Hannan, 2001; Ebbeling et al., 2004).

The top foods contributing to calories and fat in the diet were generally energy dense foods of low nutritional value. Top food categories contributing to energy were sweetened drinks, milk, and snack foods. Top food categories contributing to energy from fat were snack foods, milk, and poutine. Top foods contributing to energy and fat did not differ greatly among weight categories; minimal differences in sources of calories and calories from fat were reported. Previous studies in First Nations and Native American children have reported similar findings, where top food contributors to the diet are often energy dense, low nutrient foods (Trifonopoulos, Kuhnlein, & Receveur, 1998; Lytle et al., 2002; Stroehla, Malcoe, & Velie, 2005).

The top foods contributing to vitamins A, D, C, calcium, iron, zinc and folate were examined. Milk was among the top four food sources contributing to vitamin A, vitamin D, calcium, zinc and folate. Traditional foods, although consumed in small quantities, were among the top two contributors to both iron and zinc. It has been previously reported that the consumption of traditional foods, even in small quantities, improves micronutrient intake (Kuhnlein, Receveur, Soueida, & Egeland, 2004; Nakano, Fediuk, Kassi, Egeland, & Kuhnlein, 2005; Berti, Hamilton, Receveur, & Kuhnlein, 1999). For this reason, traditional foods should be promoted in children's diets.

In addition to examining the food sources of the aforementioned micronutrients, we also reported the risk of nutrient inadequacy. We found a low risk (<5%) of vitamin C inadequacy and children were above the EAR for iron. The risk of vitamin A, zinc and folate inadequacy was high and most children (89.8%) were below the AI for calcium intake. Because milk was found to be a major contributor to the micronutrients that were found to have high risk of inadequacy in this population, increasing the consumption of milk should be promoted. Given its contribution to fat intake, substituting 2% or homogenized milk with 1% or skim milk is recommended.

Our study found no difference in the home food environment of children in different weight categories suggesting that differences in dietary intake among weight classes was not a reflection of the availability of foods in the home. This finding might be explained by the preponderance of restaurant meals consumed. The child reported availability of soda, milk and real fruit juice was associated with the intake of these beverages, however the intake of fruits and vegetables (not including french fries) was not associated with availability in the home. The lack of association between availability and intake of fruits and vegetables was surprising, as many studies have reported this association (Neumark-Sztainer, Hannan, Story, Croll, & Perry, 2003; Hanson, Neumark-Sztainer, Eisenberg, Story, &Wall, 2005; Davis et al., 2000; Haire-Joshu & Nanney, 2002; Bere & Kelpp, 2004; Cullen et al., 2003). However, it is important to note that fruit and vegetable consumption is this population was generally quite low, making it difficult to identify differences among groups. Although a large proportion of children reported never/sometimes having chips in the home, snack foods (potato chips, Doritos, corn chips) were the top contributor to fat in the diet. It is possible, that many children who do not have access to chips in their homes are purchasing the items on their commute to and from school.

Over half (61%) of boys and girls (57%) met Tudor-Locke's (Tudor-Locke et al., 2004) recommendations for step counts. There were no differences among weight status and number of children meeting step recommendations. It is possible that the reason why we were not able to identify a clear relationship between physical activity and weight status was due to our lack of assessment of the intensity of the physical activity. Ruiz et al. (2006) recently found that vigorous activity was associated with lower body fat in children whereas total physical activity was not. Patrick et al. (2004) measured physical activity levels in children with accelerometers, enabling the assessment of physical activity intensity. They found that normal weight children engaged in more vigorous activity than at risk for overweight and overweight adolescents. These findings suggest that the intensity of the physical activity may be more important in predicting weight status than the total time spent engaging in physical activity.

Physical fitness levels in Cree children were low. Eighty three percent of children had very poor fitness levels, based on the 20-metre shuttle run test. In our study, normal weight children had higher fitness levels than both overweight and obese children. As weight status increased physical fitness levels decreased. Hanley et al. (2000) found that Aboriginal children in Sandy Lake, Ontario with the highest fitness levels had a decreased risk of overweight. The association between weight status and fitness levels suggests that increasing physical fitness levels by increasing total amount and the intensity of physical activity should be made a priority in the Cree schoolchildren.

6.1 FINAL COMMENTS

The results presented described the lifestyle factors associated with overweight and obesity in Cree schoolchildren from a rural and a remote community. We were able to report the prevalence of overweight and obesity in children from two James Bay communities. Macronutrient and micronutrient intakes and their respective food sources were reported, in addition to the risk of micronutrient inadequacies. Our study demonstrated that normal weight children had higher fitness levels, consumed more calories per kilogram body weight, milk and fiber than overweight and/or obese children. In addition, we reported the frequency of restaurant/take-out meals and their negative affect on diet quality when frequently consumed. This study was the first study with Canadian Aboriginal children, to the author's knowledge, that assessed the relationship between the availability of foods in the home and actual intake. Our findings that the availability of foods in the home did not differ between children of different weight categories suggests that differences in the dietary intake among normal weight, overweight and obese children were likely not attributable to differences in the home food environment.

The information obtained and reported in this thesis has made an important contribution to the literature in understanding what foods Cree children eat, and the contribution of specific foods, including traditional foods and milk, to the diet. In addition, these findings provide us with a more thorough understanding of the lifestyle factors associated with overweight and obesity in this population. The findings from this study will enable interventions to be targeted to the specific needs of children in Cree communities in Quebec.

6.2 FUTURE DIRECTIONS

Our study provided us with a better understanding of the prevalence of overweight and obesity, the quality of the diet, physical activity and fitness levels of Cree schoolchildren. Further research should involve inductive qualitative approaches to explore the underlying social causes for poor diet quality, inactivity, low fitness levels and frequent restaurant/take-out meals. After gaining knowledge in this area, the development of theoretically based culturally sensitive interventions will better address identified issues and barriers.

Interventions should involve the community, through participatory research, and should target multiple levels: the individual, family, community and policy. An ecological approach to lifestyle behavior change will benefit the children and communities of the James Bay Territory and will be an important step for future research and disease prevention. The ecological model contends that environmental settings have multiple physical, social and cultural dimensions that can affect various health outcomes (Raine, 2004). Ecologically based community interventions that encompass a variety of activities in different settings offer a strong potential for promoting healthy lifestyles in Aboriginal populations (Levesque, Guilbault, Delormier, & Potvin, 2005).

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APPENDICES

APPENDIX A

INFORMATION SHEET

Title of Project: **Emiyuu Ayayaachiit Awaash Project**
The Active Kids Project

Researchers at the University of Alberta:

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Members of Steering Committee

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Bella Petawabano, Director of Awash Miyupimatsiiuun (children's health and well-being), Cree Health Board, tel: (418) 923-2332, ext. 233
David Dannenbaum, Family Physician, Cree Health Board in Montreal, tel: (514) 861-2352, local 24 or at Wask Clinic 895-8833

Background:

Major changes in the lifestyles of First Nations across North America have taken place. These changes have resulted in the appearance of diseases such as obesity, diabetes and heart disease. There is a possible connection between the diet and activity of children and obesity. In this study, we would like to find out what children in Mistissini are eating, how active they are, what they think about their bodies and themselves, and their body size. This study has been discussed with teachers at your child's school. The study is supported by Public Health Department, the Principal, and the Cree Board of Health and Social Services.

Purpose:

It is important to know if children are a healthy weight. It is also important to know the types of things that might cause a child to be too big or too small. For this reason, we would like to find out how active they are and what they are eating. This information can be used to develop programs and activities to keep kids a healthy size.

Procedures:

Diet: We will ask children about the foods they eat. They will be given a questionnaire during class and then will meet with a dietitian individually to go over what they eat. We might use an assistant fluent in Cree to help us. Children will be asked what they eat each day. Each child will be asked about three different days. The child will be asked how much food they ate, types of food, and method of preparation used. Children will be asked if they eat common foods.

What children think of their size and themselves: Your child will be shown pictures of children of different sizes, and they will be asked to select the one that looks the same size as them, the one they would like to look like, and the one they think might get diabetes.

Size of children: To find out children's sizes, we will measure them (weight, height, and waist size). A member of the research team will measure your child's size. .

Activity and fitness: We will test how fit they are by asking them to run in the gym. We will ask children to attach to their clothing a small device called a pedometer that will measure how many steps they take in a day.

How Information will be used:

The information will be studied to find out if diet and activity levels are related to child size. It will also tell the researchers what children eat and if they are fit. The information may be compared to surveys in other parts of Canada and might be compared to future surveys. This information will be included as part of reports (theses) that university students will write, and will be used to write research papers that will be read by persons interested in child health.

Possible Benefits:

There is little information about what Cree children eat and what they think about the size of their bodies. There have been no studies of young children's diet, ideas of body image, and levels of physical activity and fitness. The results from this study will help the community determine: (1) what children eat, (2) if they have a proper weight and size, and (3) if they are physically fit. The information will help in the development of teaching materials and programs about healthy lifestyle and diet in the school.

Possible Risks:

The risks connected with participating in this study are minimal.

Confidentiality:

Your child's name will not appear in the computer and your child's name will never be reported. Personal records related to this study will be kept confidential. All files will be stored in a locked filing cabinet or on a private computer in the office of the researchers.

Time Commitment:

The entire test session should not exceed 3.5 hours per child in a 2-week period.

Withdrawal or non-participation in the study:

Children will be asked if they are willing to participate, and their wishes will be respected.

Children are free to withdraw from this study before or during the testing period.

If you have any questions, please contact:

Noreen Willows in Edmonton at (780) 492-3989 or by email: noreen.willows@ulberta.ca

Jane Blacksmith 923-3461 ext 205

Kitty Blacksmith 923-3461 ext 314

APPENDIX B

CONSENT FORM

A study to understand the health of Cree children
Emiyuu Ayayaachiit Awaash Project (The Active Kids Project)

Purpose:
This research project hopes to find out from children:

1. what they are eating,
2. how they feel about their bodies,
3. how active they are,
4. if they have a healthy size.

Methods:

(1) What are they eating?
A researcher will ask your child what they have eaten on three different days, what foods they eat on a regular basis, and where they eat their meals. Pictures of some commonly eaten foods, plastic copies of food, and measuring cups and spoons will be used to help children tell the researcher how much food they ate.
(2) How do they feel about their bodies?
Pictures of children will be used to find out what your child thinks their body size is, what body size they want to be, and what is an acceptable and healthy body size.
(3) How much they exercise and are they physically fit?
Children will do a test of physical fitness by running in the gym.They will wear a small device on their clothing that will count the number of steps that they take in a day.
(4) Their size
In a private booth, we will measure your child's height, weight and waist size.

Confidentiality: All information collected on your child will be recorded on paper and entered into a computer. All of the information recorded and typed will be private and your child's name will not appear in any report. Only people that are working on this study will have access to the information. A copy of the data with all names removed will be stored at the Cree Board of Health and Social Services of James Bay.

Benefits: This study may not have any direct benefits for your child. It is hoped that this information can be used to make good decisions about health programs for children.

Risks: The information provided by your child will be kept private. It is not expected that participating in this study will harm your child.

Withdrawal from the study: You can decide that you do not want your child to participate in the study. This can be done before they have started the study or before the testing is completed.

Consent Form Emiyuu Ayayaachiit Awaash Project

Please read the attached information sheet and circle your answer.

Do you understand that you have been asked to include your son or daughter in a health research study?

Yes No

Have you read and received a copy of the information sheet?

Yes No

Do you understand that there are minimal risks involved in including your son or daughter in this research study?

Yes No

Do you understand that your son or daughter can quit taking part in this study at any time?

Yes No

Do you understand that the information collected will be kept confidential?

Yes No

Do you understand who will be able to access the information collected from this study?

Yes No

Do you understand that the information collected may be compared to results from similar surveys in other parts of Canada, and that the information may also be compared to future surveys or used for other research studies?

Yes No

Do you consent to have the information collected used as described in the information sheet?

Yes No

Do you consent to have the information used for future research studies?

Yes No

Do you consent to having your son or daughter take part in this research study?

Yes No

Signature of parent or guardian	Printed name of parent or guardian
Date (dd/mm/yyyy)	Name of child

APPENDIX C

24-HOUR RECALL

Day of week:	FOOD			AMOUNT	
Time	Food Name	Method of Preparation	Where and with who food eaten	In Number	In Unit

APPENDIX D

HOME FOOD AVAILABILITY

	Never	Sometimes	Usually	All the Time
Potato chips are in my house to eat				
Fruits and vegetables are in my house to eat				
Chocolate and candy are in my house to eat				
Vegetables are on my plate at dinner				
Real fruit juice (example: Oasis, Minute Maid, Del Monte) is in my house to drink				
Pop/soft drink is in my house to drink				
Milk is in my house to drink				

How many people live in your house?

APPENDIX E

FOOD CATEGORIES

Food Group	Food Item in group
French fries	Baked and fried french fries, hashbrowns, tator tots
Sweetened drinks	Pop, iced tea, fruit drinks (eg Sunny D), and Kool-aid
Poutine	Homemade, restaurant (fries, brown sauce, mozzarella cheese)
Fruit Juice	Real fruit juice
Snack Foods	Potato chips, nachos (Doritos), tortilla chips and cheezies
Pizza	Store bought, restaurant, pizza pops
White bread	White bread, white buns, white bagels, crackers, tortilla, baked bannock
Brown bread	Brown bread
Candy	Hard and chewy
Cereal	Hot and cold, all brands
Chocolate	Chocolate bars (all types)
Chicken	Baked, fried, nuggets, chicken wings, roast
Baked goods (desserts)	Cake, cupcakes, pie, tarts, strudels, cheesecakes, pudding, banana bread, doughnut
Cookies	All types
Pasta	Pasta
Milk	Skim, 1%, 2%, homogenised
Fruit	All fruit
Vegetables	All Vegetables, including boiled and mashed potatoes
Traditional foods	Bear, beaver, moose meat, goose, rabbit, moose stew, whitefish
Butter	Butter
Peanut butter	Peanut butter
Beef	Ground beef, ribs, meatloaf, meatballs, steak, corned beef, hamburger
Lunchmeat	Ham, bologna
Eggs	Fried, boiled, scrambled
Cheese	Block cheese, cheese whiz, cheese slice, cream cheese
Yogurt	All flavours
Hot dog	Hot dogs, pogos

Pork	**Baked ham, pork chop**
Rice	**Rice (white and brown)**
Condiments	**Ketchup, mustard, soy sauce, plum sauce, BBQ sauce**
Dressings	**Salad dressing, dips, sour cream, miracle whip, mayonnaise**
Ice cream	**All flavors**
Mixed dishes	**Lasagna, meat sauce, meat pies, hamburger helper**
Macaroni and cheese	**Homemade and boxed/prepared**
Pancakes	**Waffles, pancakes, and french toast**

APPENDIX F

ANTHROPOMETRIC MEASURES DATA SHEET

Name: ______________________________ ID: _____________

Gender: M F Age:______ Class: ___________

Measurements:

Height (cm): __________

Weight (lb): __________ BMI (kg/m^2): ___________

Waist (cm): __________